

JUN 10 1910

MYCOLOGIA

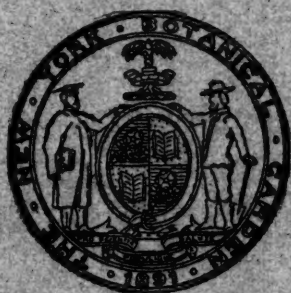
IN CONTINUATION OF THE JOURNAL OF MYCOLOGY

Founded by W. A. Kellerman, J. B. Ellis and B. M. Everhart in 1885

EDITOR

WILLIAM ALPHONSO MURRILL

Vol. II—MAY, 1910—No. 3.



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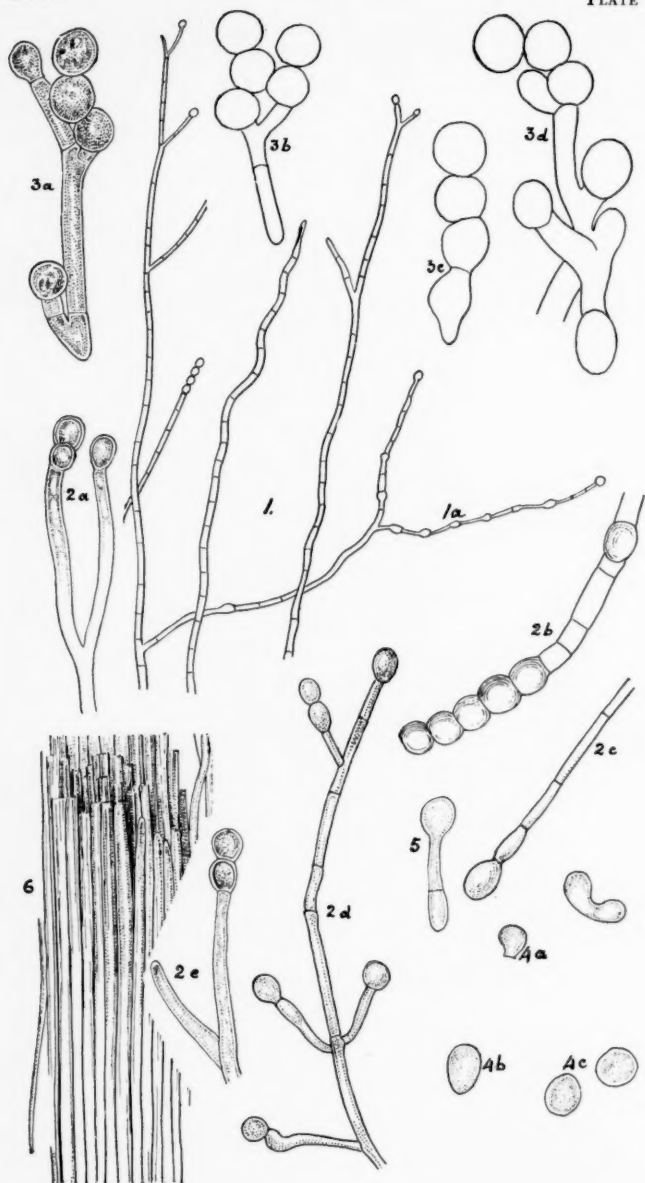
CORNELIUS L. SHEAR

PUBLISHED BIMONTHLY FOR
THE NEW YORK BOTANICAL GARDEN

By THE NEW ERA PRINTING COMPANY
LANCASTER, PA.

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MONASCUS PURPUREUS WENT

MYCOLOGIA

VOL. II

MAY, 1910

No. 3

MONASCUS PURPUREUS IN SILAGE

R. E. BUCHANAN

(WITH PLATES 22 AND 23, CONTAINING 31 FIGURES)

During the year 1909, the writer had frequent occasion to examine the molds which are common in silage not properly prepared or cared for. Such moldy silage has in several instances caused the death of farm animals, particularly horses; the symptoms of the disease being those of "forage poisoning" or "equine cerebro-spinal meningitis." Numerous cultures have been made and many molds isolated from different silages, among them several species of *Penicillium*, *Aspergillus*, *Mucor*, the mycelium of a hymenomycete (probably a *Coprinus*), and, in one instance, *Monascus*. The last mentioned was practically the only mold found in one sample. Inasmuch as no record has been found of its occurrence in America and no record of its occurrence in silage, a brief account of the fungus is here given with notes on its morphology and cultural characters.

In March, 1909, a moldy sample of silage was brought to the laboratory by a veterinarian. It was part of the contents of a silo and had been the apparent cause of the death of nine horses that had been fed upon it. Experimental evidence was brought forward later by Dean Stange, of the Department of Veterinary Medicine at the Iowa State College, which demonstrated the causal relationship of this silage to the disease. An examination of the material showed it to be thoroughly infected and matted with the mycelium of *Monascus*. Although no experimental evi-

[MYCOLOGIA for March, 1910 (2: 43-98), was issued March 8, 1910]

dence of any direct relationship between this particular organism and the death of the horses has been shown, the fungus has been thought worthy of study and record on its own account.

GROSS CHARACTERS OF THE MOLD

It is generally known that silage insufficiently packed or too dry when cut is much more apt to mold than that which is moist and well compacted. The material brought to the laboratory was much drier than usual, and matted together by mold into large masses which offered considerable resistance to being torn apart. Examination showed all parts of the silage, leaves, stalks, and ears, to be covered with a white layer of mold, forming cottony masses in some of the spaces. Where it occurred on the kernels of corn, particularly where they had been broken or crushed and the starchy endosperm exposed, the mold often assumed a pink to carmine-red color.

ISOLATION AND CULTURAL CHARACTERS

Silage agar. Five hundred grams of fresh silage was boiled for thirty minutes in one liter of tap water. This was then filtered and the silage on the filter washed with hot tap water until a liter of the decoction was secured. This was autoclaved with one and one half per cent. agar agar threads, filtered, tubed, and sterilized. Dilutions were prepared from the silage mold at points where conidia were found most abundant. These conidia germinated within twenty-four hours in most instances. The mold colonies in the lower dilutions did not develop very far on account of the luxuriance of bacterial growth. In the other plates, however, the bacterial colonies were scattered so that they did not interfere with the normal development of the mold. The inhibition of mold growth in the presence of large numbers of bacteria is a possible explanation of the fact that moist silage decays without becoming moldy through the activity of bacteria, while silage somewhat drier becomes covered with molds. Within the course of a week these mold colonies were from one half to one and a half centimeters in diameter. The outlines of the colonies are very indefinite, for the organism grows almost entirely within the substratum, forming there conidia and peri-

thecia near the center of the colony. However, aërial hyphae are usually produced, forming a cottony surface growth not more than a millimeter in height. Within a few days, the colony, particularly near the center, becomes tinged with red and in two

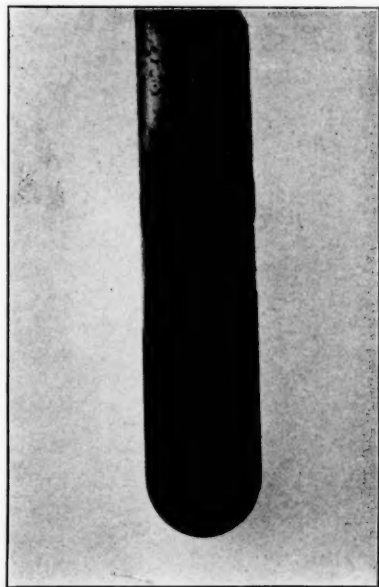


FIG. 1. Colonies of *Monascus purpureus* two weeks old in silage agar.

or three weeks is a deep carmine. This coloring gradually extends throughout the colony, always being deepest near the center.

Silage broth. A decoction of silage was prepared as outlined in the preceding paragraph, and used without further additions in 50 c.c. lots. The organism grows rather slowly in this medium, forming spherical cottony masses of hyphae not easily broken up by shaking. In one to two weeks the hyphae reached the surface of the medium (a distance of about 2 cm.) and two weeks later the surface growth attained a diameter of from 1-4 cm. This surface growth develops large numbers of aërial hyphae, not extending more than one millimeter above the surface. There

is a red pigment produced in some cases, but most cultures remain perfectly white (Fig. 2).

Glycerin solutions. Harz (1890) described *Physomyces heterosporus* from the surface of glycerin vats in a soap factory. Here, as well as in the laboratory, it grew on solutions containing as much as 30 per cent. of glycerin. To determine the ability of

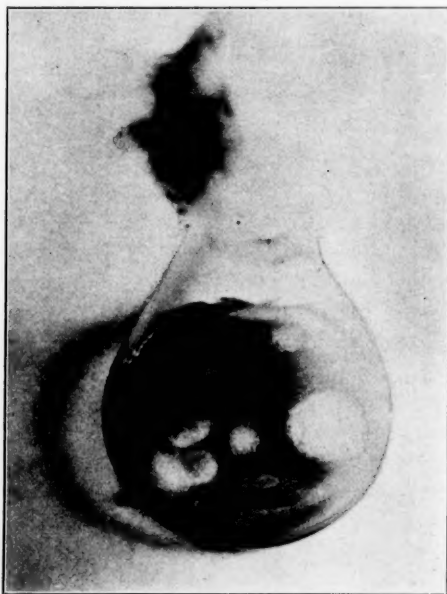


FIG. 2. Colonies of *Monascus purpureus* one month old in silage decoction.

the organism in question to use glycerin, flasks containing 100 c.c. of 5, 10, 20 and 40 per cent. glycerin in tap water were inoculated with pure cultures of *Monascus*. Growth occurred in the 5 and 10 per cent. solutions, but little or none in the 20 and 40 per cent. solutions. In the 5 per cent. solution small masses of mycelium could be observed within a few days, floating in the liquid. These continued to enlarge slowly for two months, at the end of which time they formed a semi-transparent mass of a quarter of the volume of the medium. The interior of such masses was

found to be densely matted, and of a deep carmine color. In a 10 per cent. solution of glycerin growth was slower, the colonies or mycelial balls remaining smaller and more compacted.

Rice flour. A thick paste of rice flour in tap water was prepared and sterilized in test tubes. Growth on this medium was more luxuriant than on any other tried. Within two days after inoculation, mold patches could be observed, as delicate white colonies arising from the surface of a carmine-red medium. The mycelium completely covered the surface within a few days and the medium changed to an orange-red. The surface of a culture a month old is somewhat wrinkled, the fungus forming a gray felt, with the medium itself entirely red.

MORPHOLOGY

The hyphae of the organism vary from 2 to 5 μ in diameter, branching abundantly and rather irregularly. When within the medium or just at its surface, branching is much more abundant than in the aërial hyphae. Under certain conditions, as between broken corn kernels, the hyphae may lie tightly packed side by side (pl. 22, f. 6) with little or no branching evident. The mycelium does not produce differentiated vegetative hyphae and conidiophores. The conidia may appear terminal on almost any branch. The hyphae are septate, the cell contents usually granular, and the older cells are vacuolate and contain oil drops.

Barker (1903) has noted the frequent occurrence of swellings on the hyphae of *Monascus*, particularly when the concentration of the solution had increased by evaporation, as in an old hanging drop. That this is not the only cause of such swellings is evident from pl. 22, f. 1, which shows their presence on aërial hyphae. They were also found abundantly in the 5 and 10 per cent. glycerin cultures. In size and shape these swellings approach the conidia. On starchy media, and in some others, the red coloring matter is to be found irregularly distributed through the older threads.

Conidia. The conidia are borne singly or produced in basipetal chains of 2-6 or more. They may be found on aërial hyphae, or imbedded in agar or immersed in a nutrient solution. They may even be abstricted by the tips of the filaments which invest the

perithecium. No evidence of the formation of micro- and macro-conidia could be discovered, although considerable variation in size was noted, from 6 to 10 by 7 to 15 μ . The conidia are sometimes tinged with red in old cultures; usually, however, they are colorless (*pl. 22, f. 2, 3*). Germination occurs under suitable conditions within a few hours (*pl. 22, f. 5*).

Ascocarp or "*Perithecium*." The fruiting body of *Monascus* (or *Physomyces*) was first described by Harz (1890) as a sporangium or sporocarp. More recent writers, as Barker (1903) and Olive (1905), have shown it to be of an ascomycetous type, although this claim has been denied by Ikeno (1903). All are agreed, however, that it is produced as the result of a true sexual fusion. Observations of the form in question seem to indicate that the interpretation given by Olive (1905) is the correct one. Serial sections have not been prepared, however, and the exact sequence of events cannot be accurately determined without a careful study of the subject. The perithecia develop in great numbers upon the hyphae and are generally terminal, though sometimes apparently lateral (*pl. 23, f. 8*). The young perithecia may be found in suitable media within two or three days after sowing the conidia. They develop not only on aerial hyphae, but also in the body of a medium such as agar, and nowhere were they found more abundant than in 5 and 10 per cent. glycerin solutions. So marked is this ability to produce perithecia and conidia under water, that the organism might well be classed as one of the aquatic molds. An antheridial cell fuses with a functioning egg cell, and, within this, are developed the ascogenous hyphae which ultimately form one to many asci, each typically with eight ascospores. The steps in this process can be seen only with difficulty, for the "central cell" soon becomes closely invested by sterile hyphae which branch and apparently anastomose about it.

Various steps in the development of these hyphae may be seen in the figures (*pl. 23, f. 4-10*). Sometimes branches may extend out from this investing mass (*pl. 23, f. 10*) and even produce conidia. These hyphae soon lose their contents and collapse, forming a thin membrane at maturity, which sometimes shows little evidence of its origin. *Pl. 23, f. 11* shows a perithecium

nearly mature, with the ascospores grouped within the asci. The walls of the latter soon disintegrate and the ripe perithecium filled with loose spores resembles the sporangium of a phycomycete. These perithecia vary from 25 to 50 μ in diameter. They are usually terminal at the end of a long hypha, but in some media there may be noted variations in the length of this pedicel. The spores within the perithecium number from 6 or 8 to several hundred. They are nearly spherical in shape and from 3.5 to 6 μ in diameter. They are usually tinged with brown or are slightly fuscous when mature.

SPECIFIC POSITION OF SILAGE MONASCUS

There have been described in literature five species of *Monascus*. *M. heterosporus* Schröter (*Physomyces heterosporus* Harz) differs from the form in question in having two types of conidia, having smaller conidia, and developing in much more concentrated solutions of glycerin. *M. ruber* van Tieghem differs in having larger conidia and spores and a red perithecium. *M. mucoroides* van Tieghem has larger perithecia, spores and conidia. *M. purpureus* Went agrees in all essential characters, and this organism is placed here tentatively. *M. purpureus* is the characteristic mold used by the peoples of eastern Asia in the preparation of "red rice" (Ang-quac). The fact that rice covered with this mold is used by the Chinese as food rather militates against the possibility of the form in silage being poisonous. This has not, as before stated, been investigated as yet, and further study may cause a change of view as to its specific position.

SUMMARY

A mold answering to the description of *M. purpureus* Went was found to be the typical fungus present in a moldy silage which killed eleven horses. The pathogenic properties of the organism have not as yet been wholly determined. This appears to be the first record of the occurrence of *Monascus* in this country.

CITATIONS

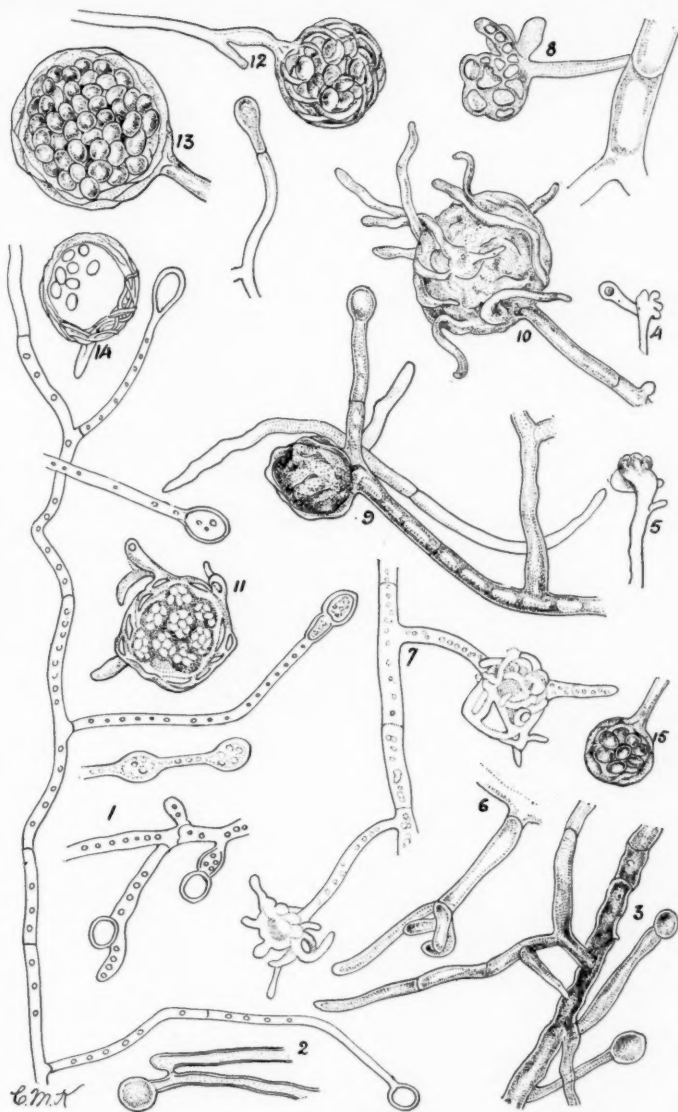
- Barker, B. T. P.** The Morphology and Development of the Ascocarp in *Monascus*. *Ann Bot.* **17**: 167. 1903.
- Harz, C. O.** *Physomyces heterosporus*. *Bot. Centralb.* **41**: 378, 405. 1890.
- Ikeno, S.** Über die Sporenbildung und systematische Stellung von *Monascus purpureus* Went. *Ber. der. d. Bot. Ges.* **21**: 259. 1903.
- Olive, Edgar W.** The Morphology of *Monascus purpureus*. *Bot. Gaz.* **39**: 56. 1905.
- Wehmer, C.** *Monascus purpureus* und der chinesische Ang-Khak. *Lafar. Hand d. tech. Myk.* **5**: 265. 1907.
- IOWA STATE COLLEGE,
AMES, IOWA.

EXPLANATION OF PLATE 22 (frontispiece)

1. Aërial hyphae with conidia and with swellings at 1a on a branch.
- 2a, 2b, 2c. Conidiophores with conidia.
- 3a, 3b, 3c, 3d. Conidiophores with conidia.
- 4a, 4b, 4c. Conidia.
5. Conidium germinating.
6. Mass of parallel hyphae from surface of moldy corn kernel.

EXPLANATION OF PLATE 23

- 1, 2. Hyphae with oil drops and conidia from glycerin solution.
3. Hyphae and conidia from silage decoction.
- 4, 5, 6. Very early stages in formation of perithecium.
- 7, 8, 9. Sterile hyphae branching and anastomosing about "central cell."
10. Sterile hyphal covering of perithecium sending out branches. These are sometimes tipped with conidia.
11. Optical section of nearly mature perithecium. Spores still within asci.
- 12, 13, 14, 15. Optical sections of mature and nearly mature perithecia, showing variations in size.



MONASCUS PURPUREUS WENT



STUDIES IN PYROPHILOUS FUNGI—II.*

CHANGES BROUGHT ABOUT BY THE HEATING OF SOILS AND THEIR RELATION TO THE GROWTH OF PYRONEMA AND OTHER FUNGI

FRED J. SEAVER AND ERNEST D. CLARK

(WITH PLATES 24-26, CONTAINING 6 FIGURES)

(FROM THE LABORATORIES OF THE NEW YORK BOTANICAL GARDEN)

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I. INTRODUCTION

Our observations noted in previous papers as to the occurrence of *Pyronema* on burned-over or heated soil had been previously noted by Kasaroff, who in this connection states that this striking phenomenon could not be explained on the assumption that the fungus had survived the heating, a subsequent infection being a much more likely explanation. The results of numerous experiments are not wholly consistent but point to certain conclusions.

Kasaroff thought that the absence of growth on unheated-soil is not due to the fact that through the process of heating more material necessary to the fungus is set free but rather that the unheated-soil contains constituents which render the growth of the fungus impossible, which constituents are destroyed by heat-

* Studies in pyrophilous fungi—I. Occurrence and cultivation of *Pyronema*, was published in MYCOLOGIA I: 131-139. 1909.

ing. It was not found possible by washing with water to wholly remove from the unheated-soil the unfavorable constituent but the soil extract contained the substances of unheated-soil which are unfavorable to the growth of *Pyronema*. Experiments with heated-soil showed that the properties favorable to *Pyronema* growth which were developed in the soil by heating may be removed from the soil by washing and in other ways. The reason for this is not clear. By boiling the extract of an unheated-soil its unfavorable properties may be partially removed. An extract of heated-soil cannot, to any great extent, render an unheated-soil a favorable nutrient medium for *Pyronema* but this may be accomplished by the addition of kainite, while the addition of charcoal, coal, and coke in various forms yields no beneficial results.

II. TOXIN THEORY

The conclusions of Kasaroff as to the reasons for the failure of *Pyronema* to grow on unheated-soil while it thrives on heated-soil seem to indicate that the unheated-soil contains a substance toxic to *Pyronema* which substance is destroyed by heat. This explanation is strengthened by the fact that other investigators have found in soils substances toxic to the higher plants, which substances inhibit the growth of such plants even in the presence of an abundance of food material.

The idea that there are toxic organic materials in soils arising from previous plant growth or otherwise, is rather a new conception but one which has been advanced and confirmed by Schreiner and his collaborators in the last few years. According to these conceptions there are definite, organic compounds in the soil, which, in the case of four substances, have been isolated, crystallized and analyzed, thus proving their composition and constitution. Some of these substances were proved to be harmful to plants by water-culture experiments, and all of them belong to types of substances that may well prove toxic to different kinds of plants on further investigation.

Such organic bodies may arise in a variety of ways, by root excretions from the growing plants, by simple decomposition and oxidation of the plant remains in the soil, and by bacterial action, etc. When one remembers that the plant body contains besides

carbohydrates and proteins, the following more or less complex substances; alkaloids, glucosides, tannins, hydrocarbons, resins, etc., it is not difficult to imagine how compounds toxic to the plant might well arise either directly or through bacterial action, slow oxidation or other deep-seated changes. Schreiner has shown that the growth of a plant in a solution makes that solution rather toxic to the growth of the same plant in the same medium because of the throwing off of toxic organic substances, rather than the depletion of the food supply by the growth of the plant.

All of this shows that in questions of soil fertility for certain plants, we must not only consider what necessary food materials are present but also determine, if possible, whether there are any toxic substances present which would check plant growth even in the presence of an abundant supply of organic and inorganic food materials.

In order to test the toxin theory with reference to the growth of *Pyronema*, an extract of unheated-soil was prepared by adding four liters of distilled water to two kilograms of unheated-soil. This mixture was stirred frequently and allowed to stand for some time and later filtered and used for the treatment of heated-soil.

On November 11, 1909, a series of experiments was conducted in which three pots of soil heated to about 160° C. for about two hours (S^1 , S^2 , and S^3) were used, with a pot of similar soil unheated as a control (C). Pot (S^1) and control (C) were treated with distilled water. Pot (S^2) was treated with extract of unheated-soil prepared in the above manner, the mixture having been allowed to stand with frequent stirring for two hours. Pot (S^3) was also treated with extract of unheated-soil on the following day, the mixture having been allowed to stand for twenty-four hours instead of two as in the preceding experiment. Each was inoculated with *Pyronema*.

On November 23, (S^1) and (S^2) showed fair growth of *Pyronema* especially on the pots, but at this time no fruit had appeared, while (S^3) showed good growth of mycelium and fruit. Control (C) gave negative results as usual.

Other experiments similar to the above were later conducted. In each case the heated-soil treated with the extract of

unheated-soil prepared in various ways proved to be fully as favorable, as culture media for *Pyronema*, as similar soil treated with distilled water, the variations being no more marked than would be expected in experiments of this nature. Heated-soil treated with distilled water and that treated with the extract of unheated-soil both gave good results.

These results indicate that if the failure of *Pyronema* to grow on unheated-soil is due to toxic constituents present in the soil these substances are not soluble in water, at least not in sufficient quantities to render extracts of such soils toxic to *Pyronema*.

III. PYRONEMA GROWTH A FOOD PROBLEM

It had often been noted in the course of our experiments that heated-soil when watered had a peculiar and characteristic pungent odor, together with the rather pleasant odor of caramel. It had also been noted that heated-soil when watered, often assumed a darker color than the same kind of soil unheated and watered in the same manner. This change of color was not universal but frequently occurred and probably depended upon the intensity of the heat.

Having repeatedly failed to show that the extract of unheated-soil had any toxic influence on the growth of *Pyronema*, we were inclined to abandon the toxin theory as an explanation of the failure of this fungus to grow on unheated-soil. It then occurred to us to reverse our experiments and try the effect of heated-soil extract with unheated-soil (p. 115). On December 2, a five-inch pot of soil was heated to a temperature of 175° C. for about two hours. This soil was then cooled and the pot placed over a filter in an extraction apparatus arranged for this purpose. Distilled water was poured into the pot until it percolated through the soil and filtered into the bottom of the extraction apparatus. A similar pot of the same kind of soil unheated was treated in the same manner. The extracts of the heated-soil and unheated-soil made in this manner were very different; the extract of the heated-soil was of a bright amber or reddish-brown color and very clear, while that of the unheated-soil was clear or slightly clouded but with no trace of the color characteristic of the heated-soil extract. The odor of the heated-

soil extract was also very characteristic, approaching that of the heated-soil itself, while the unheated-soil extract had the odor of ordinary moist earth.

When concentrated by evaporation, the residue from the heated-soil extract was of a dark brown color and possessed a very strong odor of caramel.

Other extracts of local soils were made with similar results. When heated at low temperature the color of the soil extract is often very pale, while the same soils when reheated at a higher temperature yield a much more highly colored extract, which indicates that high temperatures are necessary factors in producing a highly colored extract.

The production of an extract from heated-soil of apparently different composition from that obtained from unheated-soils and which possessed the odor characteristic of soils most favorable to *Pyronema* growth, suggested the possibility that after all we were dealing with a *food* problem, notwithstanding the fact that this had apparently been disproved by Kasaroff.

In order to test the effect of heat on other than local soils a sample of North Dakota soil was obtained through the kindness of Professor H. L. Bolley of the North Dakota Agricultural College. A sample of this soil was heated and an extract made as in previous experiments. The results were similar in every way except that the extract was of a much darker color (reddish-brown), a result which would naturally be expected by reason of the large amount of organic material in the soil. A more detailed account of the results of these tests will be given in Section VII.

Extracts of a Massachusetts soil sent by the kindness of Mr. M. G. Clark did not differ materially from extracts of local New York soils.

We should call attention here to the correlation between the temperatures necessary for the production of a strong or highly colored extract and those necessary in order to render the soil favorable to the growth of *Pyronema*. It has already been noted in a previous paper that the higher the temperatures to which the soils are heated (so far as our experiments had gone), the more favorable are the conditions for the growth of the fungus. We

have since found that the higher the temperature to which the soil is heated (up to 200° C.) the more favorable are the conditions for the production of a highly colored extract. This would at least suggest that the formation of this extract is directly concerned in the growth of *Pyronema*.

IV. BIOLOGICAL EXPERIMENTS WITH SOIL EXTRACTS

A number of extracts of heated soils were made and placed in tightly closed bottles, with no intention, however, of guarding against the possibility of air infection by fungi. Several of the extracts were evaporated down to various stages of concentration and all kept for experiment and study.

In a short time it was observed that a number of these extracts were infected with the mycelium of a fungus. In most cases the mycelium consisted of globose colonies varying from a few millimeters to a centimeter in diameter. Each consisted of a mass of mycelial threads radiating from a central point and apparently originating from a single spore. As the plants became older the mycelium became more fluffy and in some cases almost entirely filled the bottles containing the extract while in other cases the extract seemed to be less favorable for their continued growth. These colonies usually started near the bottom of the bottle, entirely immersed in the solution.

Some of this mycelium was removed from the bottles and placed on filter paper saturated with the extract. In several cases the fruit of *Pyronema* soon appeared and in some cases was produced in abundance, while in a few experiments no fruit was produced. From these experiments it became evident that the fungus which was infecting our extracts was *Pyronema*, as we had previously suspected and as the mycelium itself indicated.

So favorable are the heated-soil extracts as culture media for *Pyronema* that it has been found almost impossible to keep the extracts for any length of time in our laboratories without having them thoroughly infected with the fungus (*pl. 25, f. 2*). The same fact has already been noted with reference to heated-soil itself, this being so favorable as a nutrient medium for *Pyronema* that it is difficult to keep the fungus from invading

these substrata when exposed in our laboratory where the spores are present from previous experiments.

As stated above, the extract of North Dakota soil is much darker in color than those of local soils, a result which would be expected since the soil itself is much blacker by reason of the large amount of organic matter present. We have shown by our experiments that the color of the extract is an index to the amount of soluble substances they contain. It would naturally follow that the extract of North Dakota soil is much richer and therefore a more favorable culture medium for *Pyronema* than the extract of the other soils studied, as our experiments have later shown.

In order to run a parallel test on the unheated-soil extract and heated-soil extract, three Petri dishes were partially filled with the highly colored extract of North Dakota soil and three similar dishes filled with the extract of the same soil unheated. These were placed side by side and loosely covered, allowing abundant opportunity for air infection. In a few days, the extract of the heated-soil showed an abundant infection consisting of numerous surface colonies of various kinds of fungi and a large number of immersed colonies of what appeared to be *Pyronema*. In about a week, two of the dishes showed abundant growth of *Pyronema*, the mycelium forming a very thin but tough membrane over the surface of the extract and the fruit being produced in great abundance over its surface, especially around the outsides of the culture (pl. 24). Although the mycelium of *Pyronema* had invaded our extracts continually these were the first cultures in which the fruit was produced in the extract. The controls containing the extract of unheated-soil showed no signs of infection by fungi of any kind.

The abundant infection of heated-soil extracts with *Pyronema* while the extracts of the same soil unheated remained uninfected, is strong evidence that the fungus appears here on account of the large amount of soluble food material liberated in the soil through the process of heating.

Numerous attempts to render unheated-soil favorable to *Pyronema* growth by the addition of heated-soil extract have failed to yield the expected results. Assuming that the extract contains food material for *Pyronema* it has been difficult to account for

these failures. There are however two possible explanations: (1) that the unheated-soil contains a toxin which retards the growth of the fungus even in the presence of abundant food material, which toxin is destroyed by heat, thus rendering our problem a double one; and (2) that the nature of the food material itself is changed by the action of the unheated-soil.

Our experiments indicate that these failures to render unheated-soil favorable for this fungus are due in part to the fact that the nature of the food material is changed when this is introduced into unheated-soil. This is shown by the fact that if a pot of unheated-soil is saturated with a concentrated extract of heated-soil (reddish-brown in color) and allowed to stand for a few days, it is found that the extract has almost entirely lost its color. This result may be due to chemical combination or to the adsorptive phenomena shown by many finely divided materials such as animal charcoal, which will completely decolorize large volumes of solutions containing dyes, etc. Quantitative studies of extracts treated in this manner show that the soluble materials have been reduced to approximately the same amount contained in extract of unheated-soil. This taking out of solution of the soluble materials in heated-soil extract when added to unheated-soil, seems to account for our failure to render unheated-soil favorable to *Pyronema* in this manner, but it is possible that there are other factors concerned. This is further suggested by the following observation: While it has been impossible to render unheated-soil favorable to *Pyronema* by the addition of heated-soil extract, heated-soil which is watered with the extract of other heated-soil is much more favorable than the same kind of soil treated with distilled water, as is shown by the fact that both mycelium and fruit of *Pyronema* are produced in much greater abundance on the heated-soil watered with the extract (*pl.* 26).

V. HEATED-SOIL AND ITS EXTRACTS AS NUTRIENT MEDIA FOR FUNGI

In a previous paper, attention was called to the fact that while heating of soil destroys fungi present at the time of heating, it prepares the way for the growth of those species which are intro-

duced subsequent to heating. This conclusion was drawn from the observation of such forms as *Verticillium*, *Fusarium*, and species of various other genera of the imperfect fungi which gain entrance to the soil through the planting of seeds. The growth of such fungi was much more abundant on heated- than on unheated-soil.

Our later experiments with heated-soil extracts confirm the above observation. In addition to *Pyronema* noted above, these extracts are immediately attacked by *Penicillium*, *Mucor*, *Aspergillus*, and a number of undetermined, imperfect fungi, which grow in abundance, entirely covering and filling the extracts, especially the stronger ones, while the extracts of the same soils unheated show no fungous growth whatever. The only way in which we have been able to preserve extracts of heated-soils in our laboratory is by sterilizing and tightly sealing them in bottles. In this way we have been able to preserve them in excellent condition, while if not sterilized and tightly sealed they are soon disintegrated through the action of bacteria and fungi (*pl.* 25, *f.* 2).

In our studies of the Iowa Discomycetes it has been observed that about five per cent. of the species of this group reported from Iowa occur only on burned places. That such habitats are unusually favorable to the growth of saprophytic fungi is beyond question.

It is likely that many of the beneficial results obtained through the sterilization of soils, which effects have been attributed to the destruction of harmful fungi and bacteria in the soil, are due more to the chemical changes accompanying sterilization than to the sterilization itself.

VI. DISTILLATES FROM HEATED-SOIL EXTRACTS

Some heated-soil extract of a brownish color was distilled to one half of its original volume and the distillate collected. The residual solution in the flask had the rather pleasant odor of the heated-soil extract but the distillate had the pungent odor which is also present in the original extract. Both the distillate and the liquid in the distilling flask were acid to litmus. We thought that possibly we had been able to separate the toxic from the non-toxic acid substances by their difference in volatility and for this reason

inoculated both liquids with the spores of *Pyronema*. In a week, the flask containing the dark-colored distillation residue was filled with the mycelium, while the other flask also had a considerable growth of *Pyronema*, the latter flask and liquid being perfectly transparent, with the silvery clumps of mycelium resting on the bottom of the flask (*pl. 25, f. 1*). Thus it seemed that distillation did not cause any appreciable separation of the substances in the extract, *i. e.*, judging from its effect on the growth of *Pyronema*.

VII. CHEMICAL STUDIES OF SOIL EXTRACTS

(a) QUANTITATIVE

As already noted, the color, odor, and general appearance of heated-soil extracts indicate that the composition of such extracts must be considerably different from that of extracts of unheated-soils. We decided to investigate first the quantitative differences between the extract of heated-soil and the same kind of soil unheated. The extracts which we analyzed were made by percolating the soils in 2 kg. samples with 2 liters of distilled water and taking 50 c.c. of the first liter of extract to come through, as the sample of the extract to be analyzed. The 50 c.c. samples of the extracts were evaporated to dryness in platinum dishes, dried at 108° to constant weight and this weight recorded as total solids. The residues were carefully ashed at a low, red heat, dried and weighed again, this weight recorded as inorganic matter and the difference between this weight and the weight of the total solids recorded as organic matter. We are aware that this method of determination of organic matter by difference of the weight obtained before and after ashing is not strictly accurate, but for the comparative purposes of this work this loss of weight may be used as a satisfactory measure of the organic matter present.

Determinations were made in this manner upon samples of New York soil, Massachusetts soil, and North Dakota soil. Since it had been noted that the percolation of an extract of heated-soil through an unheated-soil reduced and finally removed its color and again made it an unfavorable medium for *Pyronema* growth, we repeated this treatment with an extract of heated-soil whose composition was known and determined the change in com-

position after it had been acted on by the unheated-soil. The results of our work on the quantitative relations of soil extracts are presented in the following table:

INCREASE OF SOLUBLE MATTER IN SOIL UPON HEATING.

			Total solid matter. Per cent.	Organic matter. Per cent.	Inorganic matter. Per cent.
New York soil (1)	{	Unheated-soil extract	0.036	0.017	0.019
		Heated-soil extract	0.138	0.094	0.044
New York soil (2)	{	Unheated-soil extract	0.038	0.022	0.016
		Heated-soil extract	0.239	0.179	0.060
Massachusetts soil	{	Unheated-soil extract	0.016	0.008	0.008
		Heated-soil extract	0.249	0.197	0.052
North Dakota soil (1)	{	Unheated-soil extract	0.100	0.050	0.050
		Heated-soil extract	1.080	0.807	0.273
North Dakota soil (2)	{	Unheated-soil extract	0.101	0.037	0.064
		Heated-soil extract	0.986	0.758	0.228

DECREASE OF SOLUBLE MATTER IN HEATED-SOIL EXTRACT BY TREATMENT WITH UNHEATED-SOIL.

			Total solid matter. Per cent.	Organic matter. Per cent.	Inorganic matter. Per cent.
New York soil (2)	{	Before treatment	0.239	0.179	0.060
		After treatment	0.031	0.019	0.012
North Dakota soil (3)	{	Before treatment	0.756	0.576	0.180
		After treatment	0.100	0.052	0.048

In examining these results one is struck by the enormous increase of soluble matter produced by heating. This increase varies somewhat with different soils, depending upon the amount of organic matter present, the length of time heated, and the intensity of the heat, but in general the soluble matter in extracts of heated-soils is from six to ten times that contained in the extracts of the same soils before heating. The increase in the organic matter is greater than that in the inorganic matter, but still the latter is evidently increased several times. With such large amounts of both organic and inorganic matter made available in soils by heating, one can understand the preference of certain plants for places which have been burned over. It is interesting to note that where the heated-soil extract was percolated through and allowed to stand for a time with the unheated-

soil, the heated-soil extract was reduced to almost exactly the same condition as the extract of the same soil before heating.

(b) QUALITATIVE

We next undertook to investigate the nature of the substances that seemed to make heated-soil extracts favorable culture media for *Pyronema* and other fungi. The pungent odor of the extracts of heated-soil together with the pronounced acidity towards litmus suggested acids, while the dark color and caramel odor suggested carbohydrates or their decomposition products. The following tests were made on heated-soil extracts before being evaporated:

Litmus paper—red.

Lead acetate—brownish precipitate.

Silver nitrate—slight precipitate (not soluble in ammonia).

Barium chloride—slight precipitate.

Alcohol—slight precipitate.

Calcium hydroxide—slight precipitate.

Ether—does not dissolve color of solution.

Molisch test—positive.

This same extract when evaporated to one fiftieth its original bulk showed the same reactions in every case except that they were far more pronounced. This concentrated extract also caused a strong reduction of Fehling solution while the blanks were negative. All of the above tests were repeated many times and the results were practically always in accord with those described above.

When unheated-soil extracts were tested in exactly the same manner, the acidity was slight as shown by litmus, barium chloride gave a slight precipitate (owing to sulphates), and silver nitrate also gave a slight precipitate wholly soluble in ammonium hydroxide (probably owing to chlorides), while all the other tests were negative.

From the qualitative tests just described we are inclined to believe that upon heating to about 160° to 180° C., the organic matter in the soil undergoes some deep-seated changes probably oxidative in nature, favored by the high temperatures, which give us the water-soluble products of an acid character producing the dark-colored solutions. The acidity of heated-soil extracts

and the heavy precipitates obtained with lead acetate, silver nitrate, and calcium hydroxide, might well be due to the presence of organic acids. The positive Molisch test indicates carbohydrates or their decomposition products, while the strong reducing action on Fehling solution would seem to confirm the assumption that carbohydrate substances are present. It is not at all impossible that the partially disintegrated cellulose of the bodies of plants previously growing on the soil, would be broken up into still smaller fragments of the original enormous molecule, and that these smaller fragments would still retain some of their carbohydrate characteristics together with the added one of acidity.

We next examined the ash of the North Dakota heated-soil extract in a qualitative manner to discover if possible the nature of the inorganic substances in the extract. The ash of the North Dakota soil was used for the reason that this was obtained in considerable quantity and that the extract of this soil was unusually favorable as a culture medium for fungi, probably owing to the large amount of organic matter originally present in the soil. The ash of the *unheated* North Dakota soil was pure white and soluble in water (100 c.c.). Upon analysis the ash was found to consist principally of the sulphates of sodium, potassium, magnesium and calcium; we were however able to find scarcely a trace of phosphates. About one-half of the ash of the extract of *heated* North Dakota soil was found to be soluble in water. In the soluble portion of the ash, sulphates of potassium, sodium, magnesium and calcium, etc., were found. In the insoluble part of the ash, we found principally calcium sulphate with some manganese, iron and traces of phosphates, etc. Calcium is thus seen to be present in considerable quantities in the extracts of heated- and unheated-soils and it may be, from the well-known stimulating and protective properties of calcium toward plants, that this element along with the organic matter helps to give heated soils some of their striking properties.

Just as this work was being brought to a close we received, upon request, a copy of an article (in galley proof) by Professor T. L. Lyon, who is publishing the results of his investigations on the effects of steam sterilization upon soils. With steam heat he found the same great increase of soluble matter over

unheated-soils that we found in the case of dry heat at 180° C. He also calls attention to the same disappearance of this soluble organic matter when soils were allowed to stand after steam sterilization, that we had noted in our work on *Pyronema*. All this shows that either dry or steam heat may cause very important changes in soils and that it is to the effect of these changes on plants, as well as to the destruction of bacteria, etc., that we must ascribe the cultural results often noted in our experiments with heated-soils.

VIII. PRODUCTS OF DRY DISTILLATION OF SOIL

In order to see if the heating of a soil would drive off substances toxic to *Pyronema*, we filled a combustion tube with soil, put it in the furnace, fitted to the tube a smaller glass tube opening under a receiver of distilled water and heated the soil. Steam came over first and then more and more of a yellowish oil which was partially suspended in the water and partially formed a scum on the surface. The oily substance had an intensely irritating and nauseating odor like that of an old, stale pipe and recalled pyridine or its allies. The liquid in the receiver was alkaline to litmus. All of this seemed to indicate pyridine bases. We watered some heated-soil with this liquid and inoculated it with *Pyronema*. In a week, the growth on this soil was as good as that on the control watered with distilled water.

The soil left in the tube was black. This was watered with distilled water and inoculated with the spores of *Pyronema* but proved to be unfavorable to its growth, although some mycelium was produced.

IX. IDENTITY OF THE FUNGUS

The fungus which we have been cultivating in the laboratory had been determined by us as *Pyronema omphalodes* (Bull.) Fuckel, although its appearance in the laboratory differed slightly from specimens of this species previously observed by us in the field. In nature the ascocarps of this species give rise to dense, confluent masses in which it is difficult to recognize the individual ascocarps, while in the laboratory the plants are thickly gregarious but not confluent to the extent that they are in nature. It therefore occurred to us that the species might be distinct.

In order to prove the identity of the species, in the spring of 1908 a pile of dead grass and leaves was raked together on the ground and burned, giving rise to a burnt place similar to those on which *Pyronema omphalodes* (Bull.) Fuckel was known to occur. As soon as the first rain occurred after the burning of this material a few of the plants from the laboratory were placed in the ashes and on the ground where the fire had been. In about ten days a good growth of *Pyronema omphalodes* (Bull.) Fuckel was found, the plants occurring in confluent masses as usual. These plants were taken into the laboratory and inoculations made from them on heated-soil. These at once produced mycelium radiating out from the point of infection and later produced an abundance of fruit, the ascocarps being scattered as is usually the case in laboratory grown material.

Some of the laboratory plants show rather well developed, hyaline, septate hairs, although these are not a conspicuous character. The color also varies much from bright rose or salmon to almost white. The paler plants are usually those produced on less favorable substrata. The fungus has doubtless been described under several names.

SUMMARY

1. Contrary to the statement of Kasaroff, our experiments have failed to show the presence of a soluble, toxic substance in unheated-soil which will retard the growth of *Pyronema* when applied to heated-soil.

2. Heating the soil to a high temperature brings about chemical changes indicated by the following: (a) The extract of heated-soil is of a bright amber or reddish-brown color and possesses a characteristic odor while the extract of unheated-soil is colorless and almost odorless, (b) the amount of soluble material in the extract of heated-soil is increased to approximately* six to ten times that of the extract of the same soil unheated.

3. The materials rendered available by the heating of the soil serve as food for *Pyronema*, as is indicated by the following: (a) The conditions necessary for the production of a highly colored extract in soil are the conditions most favorable to the growth

* The exact increase will vary with the soil and manner in which it is treated, temperature, length of time heated, etc.

of *Pyronema*, (b) the extract of heated-soil is itself so favorable as a culture medium that it is at once attacked by the fungus while the extract of the same soil unheated remains uninfected, (c) heated-soil watered with the extract of another heated-soil is much more favorable to *Pyronema* growth than similar soil watered with distilled water, the former producing mycelium and fruit in much greater abundance.

4. Distillation of heated-soil extract does not remove the properties favorable to *Pyronema*, both the colorless distillate and the highly colored distillation residue being favorable to its growth, the distillation residue, however, appearing to be more favorable than the distillate.

5. Excessive heating of soil in a combustion-tube renders it unfavorable to *Pyronema* growth. The distillate has a very offensive odor but is apparently neutral to *Pyronema* growth when applied to heated-soil.

6. It has been impossible to render unheated-soil favorable to the growth of the fungus by the introduction of the extract of heated-soil, this being apparently due to the fact that the nutrient materials in the extract are rendered insoluble by the action of unheated-soil.

7. Not only is the extract of heated-soil a favorable nutrient medium for *Pyronema*, but for other fungi as well, indicated by the fact that the extract is attacked by fungi of various kinds.

8. Soil subjected to steam or dry heat (either in a closed oven or by burning over the surface of the soil), becomes a very favorable nutrient medium for fungi of various kinds, by reason of the large quantity of food material rendered available through the heating of the materials in the soil.

We wish to acknowledge our indebtedness to Dr. W. J. Gies, of the Department of Biological Chemistry of Columbia University and Consulting Chemist to the New York Botanical Garden, for his oversight and aid throughout the course of the present work. We also extend thanks to Dr. Oswald Schreiner, of the Bureau of Soils, Washington, for numerous suggestions on various questions which have arisen pertaining to matters of soil fertility.

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THE NORTH AMERICAN MUCORALES—I

Family MUCORACEAE

DAVID ROSS SUMSTINE

INTRODUCTION

The Mucoraceae have attracted the attention of botanists for more than two hundred years and from the number of papers and theses published on the subject in Europe recently the interest remains unabated.

The American species have never been studied systematically, although local and state lists of fungi contain the names of the more common species. Pound* describes the American genera and enumerates a few species. The splendid work of Blakeslee† deals entirely with zygosporic formation.

The synonymy is exceedingly complicated and the status of many described species cannot be definitely determined. Lendner‡ reports seventeen imperfectly described species in the genus *Mucor* appearing from 1884 to 1906. The rule of priority has frequently been ignored and the same name has been used for different species. Fischer§ has unraveled the intricate synonymy of the European species.

Dried specimens soon lose their taxonomic characters, and therefore herbarium material, even when available, is seldom satisfactory for the exact determination of the specimens. The viability of the spores is lost in three to ten months and consequently cultures cannot be made from old material in order to establish the true identity of the specimens.

While this paper is intended primarily to enumerate only species seen and examined by the writer, yet, for the purpose of giving a better survey of the American species, a few have been admitted on the authority cited under Species Reported.

* Minn. Bot. Studies 1: 87-104. 1894.

† Proc. Am. Acad. 40: 205-319. 1904.

‡ Les Mucorinees de la Suisse 100. 1908.

§ Rabenh. Krypt. Fl. 1892.

At the conclusion of these studies, my own material will be placed in the Carnegie Museum, Pittsburgh, and in the New York Botanical Garden. This will be done in the hope that other mycological workers who are not directly connected with large public institutions will also deposit their material in institutions where it will be available to future students.

I am indebted to Dr. W. J. Holland, of the Carnegie Museum, Pittsburgh, for assistance in making collecting trips in Pennsylvania. My thanks are especially due to Dr. N. L. Britton for the opportunity of examining the specimens in the herbarium and consulting the literature in the library of the New York Botanical Garden. The various members of the staff of the Garden have very kindly and cheerfully rendered valuable service in the preparation of this paper.

Order MUCORALES

Saprophytic or parasitic fungi with well-developed mycelium, the mycelium branched and unicellular. Reproduction sexual (zygospores) and asexual (spores produced in sporangia or conidia produced singly or in chains).

Schroeter* recognizes five families, *Mucoraceae*, *Mortierellaceae*, *Choanophoraceae*, *Chaetocladiaceae*, and *Piptocephalidaceae*. The total number of species for the whole world is less than 150. Most of these are described from Europe.

Family MUCORACEAE

Asexual reproduction by spores in sporangia with columella or sometimes in sporangioles without columella. Sexual reproduction by zygospores formed on the mycelium or on aerial filaments by the union of two copulating branches (gametes).

KEY TO THE GENERA

1. *Simplices*

Sporangiophores simple, unbranched.

Sporangiophores arising from stolons, sporangial membrane not cuticularized.

Sporangiophores arising from the nodes of the stolons.

1. MUCOR.

Sporangiophores arising from the internodes of the stolons.

2. ABSIDIA.

* Pflanzenfamilien 1¹: 123. 1892.

- Sporangiophores arising from the mycelium, sporangial membrane not cuticularized.
- Sporangiophores long, with metallic luster. 3. PHYCOMYCES.
- Sporangiophores variable in length, white, gray, brown. 4. HYDROPHORA.
- Sporangiophores brown or brownish with spiny aerial filaments. 5. SPINELLUS.
- Sporangiophores arising from the mycelium or from mycelial swelling, sporangial membrane cuticularized.
- Sporangiophores arising from mycelial swellings. 6. HYDROGERA.
- Sporangiophores not as above. 7. PILAIRA.

2. *Ramosi*

- Sporangiophores variously branched.
- Sporangiophores dichotomously branched. 8. SYZYGITES.
- Sporangiophores without terminal sporangia, branches circinate. 9. CIRCINELLA.
- Sporangiophores with terminal sporangia, branches with sporangioles.
- Sporangioles on dichotomous branches. 10. THAMNIDIUM.
- Sporangioles on circinate branches. 12. HELICOSTYLUM.
- Sporangioles on straight branches, arising from bulbs. 11. BULBOTHAMNIDIUM.
- Sporangiophores with sporangia only.
- Branches long or short, zygospores with nearly equal suspensors. 13. CALYPTROMYCES.
- Branches as above, zygospores on dichotomous branches, suspensors unequal. 14. ZYGORHYNCHUS.

1. MUCOR (Mich.) L., Sp. Pl. 1185. 1753

Ascophora Tode, Fung. Meckl. 1: 13. 1790.

Type species, *Ascophora Mucedo* Tode.

Rhizopus Ehrenb. Nov. Acta Acad. Leopold 10¹: 198. 1820.

Type species, *Rhizopus nigricans* Ehrenb.

ORIGINAL DESCRIPTION: Fungus vesicula subrotunda, in qua semina numerosa affixa, receptaculis criniformibus constans.

Type species, *Mucor Mucedo* L.

Sporangiophores simple, usually growing in clusters of two, three, or five from the nodes of the stolons, enlarged below the sporangia forming an apophysis; mycelium white at first, then brown, growing by stolons attached at different places to the substratum by rhizoids; zygospores borne on the mycelium, naked.

Robert Hooke (*Micrographia* 125, *pl. 12, f. 1.* 1665) describes and figures a mushroom growing on "divers kinds of putrefied bodies, such as skin raw or dressed, flesh, blood, milk, green cheese, rotten sappy wood, or herbs, leaves, bark, roots of plants." The plants were also found "to bespeck and whiten over the red covers of a small book bound in sheep skin. This kind of leather gathers mould more easily than other leathers."

The plants are described as long, cylindrical with transparent stalks bending over with the weight of a round knob that grows on the top of them. The illustrations might easily be our common black mould but the habitat makes it somewhat doubtful.

Malpighius (*De Plant. in aliis Veg.* 65, *pl. 28, f. 108.* 1687), describes and figures accurately the so-called *Mucor stolonifer*. He observed the plants "*in Cucurbitae putrescente pericarpio.*" He observed clearly the rhizoids, *radicibus minimis*, and the clusters of sporangiophores arising from the nodes of the stolons "sometimes five, sometimes three, and not rarely two." His description and discussion leave no doubt as to the identity of his plants (see Wilson, *Bull. Torrey Club* 33: 557. 1906).

Micheli *l. c.* first establishes the genus *Mucor* and divides it into two sections, *Mucores pediculo donati* and *Mucores pediculo-carentes*. The first species enumerated is *Mucor vulgaris* and characterized as follows, "*capitula lucida per maturitatem nigra, pediculo griseo.*" He cites Malpighius, Hooke and Sterbeek. The brief description and the illustration are not conclusive as to the identity of his species but when studied in connection with his observations, it is very evident that he had before him *Mucor stolonifer*.

In the *Species Plantarum*, Linnaeus enumerates under the genus *Mucor* eleven species but only one, *Mucor Mucedo*, is now retained under the genus, which becomes the type of the genus. He cites *Mucor vulgaris* of Micheli as a synonym. Without doubt, *Mucor vulgaris* and *Mucor Mucedo* refer to the same plant. A careful study of the above citations leaves no doubt as to the identity of the plants of Malpighius, Micheli and Linnaeus.

The following citations may be given as additional or corroborative evidence that the early botanists had before them the *Mucor Mucedo* of Linnaeus with the identity as above indicated:

Gleditsch (Meth. Fung. 158 seq. 1753) describes a number of *Mucors* among which is *M. vulgaris*. He cites Micheli, Malpighius and Linnaeus. Haller (Hist. Stirp. Helv. 3: 113. 1768) lists *Mucor Mucedo* growing on bread. Batsch (Elench. Fung. 157. 1783) enumerates and describes six *Mucors*. The first one is *Mucor Mucedo*. Fries (Syst. Myc. 3: 310. 1829) lists *Ascophora Mucedo* but gives as synonym *Mucor Mucedo*, *Auct. pro parte*. The description fits very clearly the species under consideration.

These various names were applied to the plant of Linnaeus until 1850, when Fresenius (Beitr. Myk. 4-13. pl. 1, f. 1-12. 1850) described and figured quite a different plant under the name *Mucor Mucedo*. His plant was no other than *Hydrophora stercorea* Tode (see under *Hydrophora*), and quite distinct from *Mucor Mucedo* L. But since the time of Fresenius many authors have considered *Mucor Mucedo* L. and *Mucor Mucedo* Fres. synonymous, although the plants described by these two men are very different.

Zimmerman (Das Genus Mucor 4. 1870) recognized the real identity of *Mucor Mucedo*. He says that the description and figure of Malpighius undoubtedly refer to *Mucor stolonifer* Ehrenberg but he ignores the *Mucor Mucedo* of Linnaeus.

KEY TO THE SPECIES

- | | |
|--|-------------------------|
| Rhizoids abundant, at the nodes of the stolons, spores large, irregular. | 1. <i>M. Mucedo</i> . |
| Rhizoids few, short, spores smaller, oval or round. | 2. <i>M. arrhizus</i> . |
| Rhizoids few, sporangiophores with swellings. | 3. <i>M. nodosus</i> . |

1. MUCOR MUCEDO L. Sp Pl. 1185. 1753. Not *Mucor Mucedo* Fres.

Ascophora Mucedo Tode, l. c. 1790.

Mucor stolonifer Ehrenb. l. c. 1818.

Rhizopus nigricans Ehrenb. l. c. 1820.

Mucor ascophorus Link, Willd. Sp. Plant. 61: 85. 1824.

See Fischer l. c. for further synonymy.

This is the common black mould of bread and of decaying vegetable matter. The shape and the size of the spores are exceedingly variable.

SUBSTRATA: On bread, pumpkin, squash, sweet potato, fruits.

SPECIMENS EXAMINED: Delaware, *Cummins*; Kansas, *Fung. Columb.* 1673; Kingston, Jamaica, *Ellis Collection* 66; New Jersey, *Ellis Collection* 1628; New York, *Underwood* and *Cook* 89; Nebraska, *Pound*; Pennsylvania, *Sumstine*; South Carolina, *Ravenel* 622, 89; Washington, D. C., *Galloway*.

ILLUSTRATIONS: *Malpighius*, *l. c.* pl. 28, f. 108, e, f, g; *Corda*, *Icon Fung.* 1: pl. 11, f. 78, pl. 12, f. 83; *Link*, *Ges. Naturf. Freunde Berl. Mag.* 3: pl. 2, f. 43; *Fischer*, *l. c.* f. 39.

2. *MUCOR ARRHIUS* (*Fischer*) *Hagem*, *Norweg. Mucorineen* 37. 1908

Rhizopus arrhizus *Fischer*, *l. c.* 233. 1892.

The stolons are less developed than in the preceding species; the sporangiophores grow from the nodes in umbels or corymbs; the spores are round or oval, irregular, angular.

SUBSTRATA: On bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: *Hagem*, *l. c.*

3. *Mucor nodosus* (*Namysl.*).

Rhizopus nodosus *Namysl.* *Bull. Acad. Sci. Cracovie.* 1906.

(This paper was not available.)

The few rhizoids, the branching sporangiophores, the somewhat flattened columella, and the peculiar nodes or swellings in the sporangiophores characterize this species.

SUBSTRATA: On sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: *Lendner*, *l. c.* 122.

SPECIES REPORTED

Mucor rhizopodiformis *Cohn*, *Zeitschr. f. Klinische Medicin* 7: 148. 1884. *Rhizopus Cohnii* *Berlese & de Toni*; *Sacc. Syll. Fung.* 7: 213. 1888.

No. 1950 in the *Ellis Collection* is labeled *Rhizopus Cohnii*. The plants were found growing "in kraut barrel attached to sides." The spores are small and regular in form. Attempts to germinate some of the spores were unsuccessful. The species is considered pathogenic in dogs and rabbits.

DOUBTFUL SEPCIES

Mucor inaequalis Peck, Ann. Rep. N. Y. State Mus. 26: 79. 1874.

2. *ABSIDIA* Van Tieghem, Ann. Sci. Nat. VI. 4: 350. 1876

ORIGINAL DESCRIPTION: En résumé, les *Absidia* sont caractérisés vis-à-vis de toutes les autres Mucorinées: 1° par le développement de leur appareil sporangial en arcades paraboliques, issus l'une de l'autre en sympode et couronnées chacune par un bouquet de sporanges piriformes; 2° par les rameaux verticillés, cuticularisés et colorés, qui viennent envelopper et protéger la zygosspore.

Ces caractères placent ce genre entre le *Rhizopus* et le *Phycomyces*, mais plus près du premier. (In part.)

Type species, *Absidia capillata* Van Tieghem.

Sporangiophores in groups of 2-5, developed from the internodes of the stolons, terminated by a pear-shaped sporangium with columella; zygosporoes produced on the stolons, enveloped by circinate, cuticularized filamentous threads growing from the suspensors.

1. *ABSIDIA SPINOSA* Lendner, Mucor. Suisse

132. 1908

? *Absidia cylindrospora* Hagem, Unters. Norweg. Mucor. 45. 1908.

Lendner gave a preliminary description of this species in Bull. de l'Herb. Boissier II, 7: No. 3. 1907. The spine growing from the extremity of the columella suggested the name *spinosa*.

SUBSTRATA: Grown in the laboratory on sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine* (laboratory culture).

ILLUSTRATION: Lendner, l. c. f. 46.

3. *PHYCOMYCES* Kunze, Myk. Hefte 2: 113. 1823

ORIGINAL DESCRIPTION: Flocci decumbentes, continui, simplices, flaccidi. Sporidia oblonga circa vesiculam pyriformem apice insidentem collecta.

Type species, *Ulva nitens* Agardh, Syn. Alg. Scand. 46. 1817.

Sporangiophores erect, simple, terminated by a large sporangium, growing singly from the mycelium; zygospores borne on the mycelium, suspensors with dichotomously branched outgrowths, copulating branches tong-shaped.

1. *PHYCOMYCES NITENS* (Agardh) Kunze, *l. c.* 1823

Uva nitens Agardh, *l. c.* 1817.

Periconia phycomyces Bonord. Hbdk. Allg. Myk. 113. 1851.

Mucor romanus Carnoy, Bull. Soc. Royal Bot. Belg. 9: 157. 1870.

Mucor violaceus Bref. Bot. Unters. 4: 56, 92. 1881.

The large, metallic-like sporangiophores enable one to identify this species even without lens or microscope. It prefers oily or greasy substances and can easily be grown on ground flax seed. It has been reported as growing on a mushroom, *Collybia dryophila* (Bull.) Fr. (Peck, Ann. Rep. N. Y. State Mus. 31. 1909).

SUBSTRATA: On ground flax seed, cornmeal, horse manure.

SPECIMENS EXAMINED: North Carolina, *Wood*; New York, *Mrs. N. L. Britton*; Oregon, *Lake*; Pennsylvania, *Sumstine*, *Schweinitz*.

ILLUSTRATIONS: Carnoy, *l. c.* pl. 1, f. 1-4, pl. 2, f. 1-3, pl. 3, f. 1-7; Van Tieghem, Ann. Sci. Nat. V. 17: pl. 20; Bainier, Étude, pl. 1, f. 12-15.

4. *HYDROPHORA* Tode, Fung. Meckl. 2: 5. 1791

Mucor (Mich.) L. (Many authors since 1850.)

ORIGINAL DESCRIPTION: Fungus globosus, stipitatus, capitulo aqueo; stipite capillari subrecto; fructificatione ignota.

Type species, *Hydrophora stercorea* Tode.

Sporangiophores simple, arising singly from the mycelium, terminated by a sporangium with columella; zygospores borne on the mycelium, naked, copulating branches straight. The species under Section 1. Mono-Mucor, of Fischer (Rabenh. Krypt. Fl. 1st: 184. 1892), belong to this genus.

Under this genus, Tode placed three species, *H. minima*,* *tenella*,† *stercorea*. The descriptions of the first and second are

* Fischer (Rabenh. Krypt. Fl. 1st: 297) thinks this is a *Syncephalis*, probably *S. nodosa*.

† See under *Pileira* for further discussion.

too indefinite for exact determination. The characterization of the third species seems to agree with the plants now usually passing under the name *Mucor Mucedo* L. Tode found his plants on human dung but he also discovered some plants on dog dung which agree in every way with the former except in size.

There may be some doubt as to the absolute identity of Tode's plants but authors generally have cited his name as a synonym of the so-called *Mucor Mucedo* L. It is, at least, the oldest name given to dung inhabiting Mucors with simple sporangiophores unless some one can prove that Haller's species, *Lycogola petiolatum*, *aquosum*, *flavescens*, is a *Mucor* (Haller, Hist. Stirp. Helv. 3: 112. 1768).

KEY TO THE SPECIES

Sporangiophores erect.

Columella cylindric or somewhat globose.

1. *H. stercorea*.

Columella pear-shaped.

2. *H. Fischeri*.

Sporangiophores flaccid, decumbent.

Sporangia and sporangiophores brownish or yellow-brown.

3. *H. Taeniae*.

Sporangia and sporangiophores yellow or refusecent.

4. *H. rufescens*.

1. *HYDROPHORA STERCOREA* Tode, l. c. 1791

? *Mucor caninus* Pers. Obs. Myc. 1: 96. 1796.

Mucor stercoreus Link, Willd. Sp. Pl. 6¹: 90. 1824.

Mucor Mucedo Fres. Beitr. Myc. 7. 1850. Not *Mucor Mucedo* L.

Mucor Mucedo L. (Many authors since 1850.)

This plant varies considerably in the size of the sporangia and the spores but the shape of the spores is rather constant. I have not found branching sporangiophores although they have been reported (Lendner, Mucor. Suisse 68. 1908). The species is also considered pathogenic (Neveu-Lemaire Precis de Parasitologie humaine. 1906).

SUBSTRATA: On human and horse dung.

SPECIMENS EXAMINED: Indiana, *Arthur*; New Jersey, *Ellis N. A. F.* 972; Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fres. l. c. pl. 1, f. 1-12; Fischer, Rabenh. Krypt. Fl. 1⁴: f. 30-31.

2. *Hydrophora Fischeri* nom. nov.

Mucor piriformis Fischer, l. c. 191. 1892.

Not *Mucor pyriformis* Leers, Fl. Herborn. 288. 1789.

It is unfortunate that Fischer's name had been used before and therefore must be reduced to synonymy. The pear-shaped columella suggested the name given by Fischer.

The specimens referred to this species have a smaller columella and larger spores than those given in the original description (see Torrey 9: 143. 1909).

SUBSTRATA: On dung of deer.

SPECIMENS EXAMINED: Pennsylvania, Sumstine.

ILLUSTRATIONS: Fischer, l. c. f. 30 c.

3. *Hydrophora Taeniae* (Fairman).

Mucor Taeniae Fairman, Proc. Roch. Acad. Sci. 533. 1891.

The author of this interesting species gives the following description, "Sporangiferous hyphae erect, rarely if ever branched septate, yellow, 7μ diam.

"Sporangia globose, brownish or yellow brown, smooth, mostly 40μ in diam. Columella elliptical or sub-sphaeroidal, at times with contraction at the base, brownish.

"Spores globose, or ellipsoid, light yellow, $3-5\mu$ in diam. with smooth epispore. Zygospores not observed."

SUBSTRATA: On segments or joints of tape worm (*Taenia solium*).

SPECIMENS EXAMINED: New York, Fairman.

ILLUSTRATIONS: Fairman, l. c. pl. 4, f. 4-6.

4. *Hydrophora rufescens* (Fischer).

Mucor rufescens Fischer, l. c. 192. 1892.

Mucor rubens Vuillemin, Bull. Soc. Myc. Fr. 3: 111. 1887.

Vuillemin's description is incomplete but in all probability he had the same plant before him as Fischer. The latter author cites *Mucor rubens* as a synonym of his species.

The sporangiophores are very flaccid and form a network over the substratum.

SUBSTRATA: On elephant dung.

SPECIMENS EXAMINED: New York, Sumstine.

SPECIES REPORTED

Mucor mucilagineus Bref. Bot. Unters. 4: 58. 1881.

This species has been reported from Michigan by Kauffman (Ann Rep., Mich. Acad. Sc. 8: 28. 1905). The author appends a note as follows, "Probably a variety of the type from which it differs slightly. On decaying fungi."

5. SPINELLUS Van Tieghem, Ann Sci. Nat. VI. 1:

66. 1875

ORIGINAL DESCRIPTION: Par leur mycélium aérien, dont les filaments se cuticularisent, brunissent et se couvrent de petits rameaux épineux, par leur tube fructifère également cuticularisé et coloré en brun foncé, y compris la columelle qui s'insère au-dessus du point d'attache du sporange sur le filament, par leurs spores noirâtres, enfin par la courbure en mors de pince des deux rameaux renflés qui se conjuguent pour former la zygospore, ces deux espèces se distinguent de tous les *Mucor* à moi connus et doivent former un genre distinct, qui vient se placer entre le *Phycomyces* et le *Rhizopus*, non loin du *Sporodinia*. Son nom, *Spinellus*, est tiré des petites épines qui hérissent les filaments mycéliens et dont le développement est lié au mode de nutrition et au parasitisme de ces plantes.

Type species, *Mucor fusiger* Link = *Mucor rhombosporus* Ehrenb.

Sporangiophores erect, simple, brown or yellowish-brown, with thorny, branched aerial filaments bearing the zygospores.

KEY TO THE SPECIES

Spores narrowly ellipsoid with obtuse or rounded ends.

1. *S. rhombosporus*.

Spores broadly ellipsoid with acute ends.

2. *S. macrocarpus*.

1. SPINELLUS RHOMBOSPORUS (Ehrenb.) Pound, Minn. Bot.

Studies 1: 96. 1894

Mucor rhombosporus Ehrenb. Syll. Myc. Berol. 25. 1818.

Mucor fusiger Link, Verh. Naturf. Freunde Berl. Mag. 1: 108. 1820.

Spinellus fusiger Van Tieghem, l. c. 1875.

This species grows on agarics, especially species of *Mycena*. The aerial filaments with thorny branches and the spores with obtuse ends distinguish it.

Ehrenberg described the species first as *Mucor rhombosporus*

but later says that he made a mistake in the examination of the spores. Link suggested verbally to him the name *Mucor fusiger* which Ehrenberg prefers and accepts but according to the rules of priority the former name must be retained.

SUBSTRATA: On decaying agarics.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Van Tieghem, *l. c. pl. 1, f. 29-37*; Bainier, *Étude, pl. 3, f. 1-13*.

2. *SPINELLUS MACROCARPUS* (Corda) Karst., *Myc. Fenn.* 4: 73.
1878

Mucor macrocarpus Corda, *l. c. Fung.* 2: 21. 1838.

This species differs from the other chiefly in spore character as shown in the key.

SUBSTRATA: On decaying agarics.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATION: Corda, *l. c. pl. 12, f. 84*.

6. *HYDROGERA* Web. and Wigg., *Prim. Fl. Holsat.* 110.
1780.

Pilobolus Tode, *Schrift. Gesell. Naturf. Freunde Berl.* 5: 46.
1784.

Type species, *Pilobolus crystallinus* (Web. and Wigg.) Tode.

ORIGINAL DESCRIPTION: Capsula humido aquoso repleta, pileo hemisphaerico tecta.

Type species, *Hydrogera crystallina* Web. and Wigg.

Sporangiophores simple, erect or oblique, colorless or with orange colored contents, arising from swellings in the mycelium and ending with ellipsoid swellings beneath the sporangium; sporangia lenticular, with columella, membrane cuticularized above but disappearing in the lower half; zygospores borne on the mycelium, naked, with tong-shaped copulating branches.

KEY TO THE SPECIES

Spores elliptic.

Spores small, $3-6 \times 6-10 \mu$.

Spores variable, larger, $6-10 \times 12-20 \mu$.

Spores ellipsoid or nearly globose, $10-12 \times 12-14 \mu$.

Spores globose, variable in size.

1. *H. obliqua*.

2. *H. Kleinii*.

3. *H. longipes*.

4. *H. Oedipus*.

1. HYDROGERA OBLIQUA (Scop.) O. Kuntze, Rev. Gen. Pl.
2: 855. 1891

Mucor obliquus Scop., Fl. Carn. 2: 494. 1772.

Hydrogera crystallina Web. and Wigg., l. c. 1780.

Pilobolus crystallinus (Web. and Wigg.) Tode, l. c. 1784.

? *Mucor urceolatus* Dicks., Pl. Crypt. Brit. 1: 25. 1785.

Scopoli gives a good description of this species and Weber and Wiggers cite his species as follows, "*Mucor obliquus* Scop. Carn. n. 1643 cum nostra convenit." Tode bases his genus on *Hydrogera crystallina* and cites as a synonym *Mucor obliquus*.

The sporangium rests somewhat on the side of the subsporangial swelling. The mycelial swelling is buried in the substratum.

SUBSTRATA: On dung of horse.

SPECIMENS EXAMINED: Pennsylvania Ellis & Ev. N. A. F. 831, Sumstine; New York, Sumstine.

ILLUSTRATIONS: Tode, l. c. pl. f. 1-7; Link, Ges. Naturf. Freunde Berl. Mag. 3: pl. 2, f. 49-50; Bull. Herb. Fr. pl. 480, f. 1.

2. HYDROGERA KLEINII (Van Tieghem) O. Kuntze, l. c. 1891
Pilobolus Kleinii Van Tieghem, Ann. Sc. Nat. VI. 4: 337. 1876.

This species is nearest *H. obliqua* but may be distinguished by the form of the spores, by the mycelial swelling, and by the smaller sporangiophores.

SUBSTRATA: On horse dung.

SPECIMENS EXAMINED: Pennsylvania, Sumstine.

ILLUSTRATIONS: Van Tieghem, l. c. pl. 10, f. 6-10.

3. HYDROGERA LONGIPES (Van Tieghem) O. Kuntze, l. c. 1891
Pilobolus longipes Van Tieghem, l. c. 6, 4: 338. 1876.
Pilobolus roridus Bref. Bot. Unters. 4: 70. 1881.

This species is possibly mistaken for one of the other species and therefore has not been previously reported for America. The long swelling at the base of the sporangiophore and the elliptic-spherical spores are determinative characters.

SUBSTRATA: On horse dung.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*; New York, *Sumstine*.

ILLUSTRATIONS: Van Tieghem, *l. c.* pl. 10, f. 10-15; Bref. *l. c.* pl. 4, f. 17; Bainier, *Étude*, pl. 2, f. 11-12.

4. HYDROGERA OEDIPUS (Mont.) O. Kuntze, *l. c.* 1891
Pilobolus Oedipus Mont. Mem. Soc. Linn. de Lyons 1. 1826.
 (The original description was not seen by me.)

This species may be known by the rather short sporangiophores and the globose spores of unequal size.

SUBSTRATA: On dung of horse.

SPECIMENS EXAMINED: The following collections are in the Herbarium of the New York Botanical Garden but only the ejected sporangia caught on paper and on leaves are found in the packets and therefore the determinations were made from spore characters only.

Canada, *Ellis*; Kansas, *Kellerman*; Louisiana, *Langlois*; Nebraska, *Williams*; Pennsylvania, *Meehan*, *Rothrock*, *Scribner*.

ILLUSTRATIONS: Bainier, *Étude*, pl. 2, f. 1-10.

SPECIES REPORTED

Hydrogera rorida O. Kuntze, *l. c.* 1891. *Mucor roridus* Bolt. Hist. Fung. 3: 168. 1789. *Pilobolus roridus* Pers. Syn. Fung. 117. 1801.

This species is reported by Pound in Minn. Bot. Studies 1: 101. 1894.

7. PILAIRA Van Tieghem, Ann. Sci. Nat. VI. 1: 51. 1875

ORIGINAL DESCRIPTION: Les deux caractères que nous venons d'assigner au genre *Pilobolus*, à savoir la déhiscence spéciale du sporange, déterminée par la structure même de cet organe, et sa projection, liée au contraire à la forme et à la structure du filament qui le porte, sont, avons-nous dit, indépendants l'un de l'autre. On conçoit donc que le premier puisse exister sans le second, et c'est précisément ce qui a lieu dans le genre nouveau que nous allons étudier maintenant. Le sporange y possède la même structure, et par conséquent le même mode de déhiscen-

ce que chez les *Pilobolus*; mais il n'est pas projeté dans l'atmosphère, et à cette absence de projection correspond naturellement l'absence de la structure et de la forme si caractéristiques du filament sporangifère qui déterminent ce phénomène les *Pilobolus*. . . . C'est de cette faculté de soulever son sporange au lieu de le projeter que j'ai tiré le nom générique *Pilaira*, par opposition à celui de *Pilobolus*.

Type species, *Pilaira Cesatii* Van Tieghem = *Pilobolus anomalus* Cesati.

This genus is chiefly distinguished from *Hydrogera* by the absence of mycelial and subsporangial swellings.

Fischer (Rabenh. Krypt. Fl. 1⁴: 257) cites *Hydrophora tenella* Tode as a synonym of *Pilaira nigrescens* Van Tieghem. If the synonymy of these two species could be established, then the genus *Pilaira* would become a synonym of *Hydrophora* with *H. tenella* as the type of the latter genus. This would change the conception of the genus *Hydrophora*. The lack of type specimens and the very brief diagnosis of *Hydrophora tenella* do not justify such a conclusion. The genus of Van Tieghem therefore stands.

I. PILAIRA FIMETARIA (Link) Pound, Minn. Bot. Studies 1: 100.
1894

Mucor fimetarius Link, Ges. Naturf. Freunde Berl. Mag. 3: 30.
1809. Berl. Mag. Gesell. Naturf. Freunde.

Pilobolus anomalus Cesati, Bot. Zeit. 9: 647. 1851.

Hydrophora fimetaria Fries, Syst. Myc. 3: 313. 1829.

Ascophora Cesatii Coemans, Acad. Roy. Sci. Belg. 30: 63. 1861.

Pilaira Cesatii Van Tieghem, Ann. Sci. Nat. VI. 1: 51. 1875.

Link's name is evidently the oldest that can with any certainty be applied to this species.

The sporangia are black when mature, columella depressed globose, spores oval or elliptic oval. The zygospores are borne on tongue-shaped copulating branches.

SUBSTRATA: On decoction of manure.

SPECIMENS EXAMINED: Pennsylvania, Sumstine. (In laboratory cultures.)

ILLUSTRATIONS: Van Tieghem, l. c. pl. 1, f. 14-24; Coemans, l. c. pl. 2, f. e.

8. SYZYGITES Ehrenb. Syll. Myc. Berol. 25. 1818

Sporodinia Link, Willd. Sp. Pl. 6¹: 94. 1824.

Type species, *Sporodinia grandis* Link.

? *Azygites* Moug. et Fries; Fries, Syst. Orb. Veg. 1: 364. 1825.

ORIGINAL DESCRIPTION: Hic fungus est verus *Mucor erectus*, *Aspergillo* maximo simillimus, simul vero est vera conjugata. Ab *Aspergillo* recedit vesicis lateralibus binis in corpus fusiforme connascentibus. Moventur semina.

Type species, *Syzygites megalocarpus* Ehrenb.

Sporangiophores erect, septate, repeatedly dichotomously branched, terminated by a sporangium with columella; zygospores on special, upright, dichotomously branched filaments.

Link bases his new genus *Sporodinia* on *Aspergillus globosus* Link (Obs. 1: 14. f. 15. 1809). There is no such species given on page 14 but on page 16, figure 15 is cited under the name *Aspergillus maximus*. The figure is very clearly the species under consideration.

The genus *Azygites* is not clear.

1. SYZYGITES ASPERGILLUS (Scop.) Pound, Minn. Bot. Studies

1: 96. 1894

? *Mucor ramosissimus* Haller, Hist. Stirp. Helv. 3: No. 2167. 1768.

Mucor aspergillus Scop. Fl. Carn. 2: 494. 1772.

Mucor ramosus Bull. Hist. Champ. Fr. 116. 1791.

Mucor flavidus, Pers. Obs. Myc. 1: 95. 1796.

Mucor rufus Pers. Syn. Fung. 200. 1801.

Aspergillus maximus Link, l. c. 1809.

Syzygites megalocarpus Ehrenb. l. c. 1818.

? *Monilia spongiosa* Pers. Myc. Europ. 1: 30. 1822.

Sporodinia grandis Link, l. c. 1824.

Mucor capitato-ramosus Schw. Trans. Am. Phil. Soc. II. 4: 285. 1832.

Sporodinia dichotoma Corda, Ic. Fung. 1: 22. 1837.

? *Nematogonium fumosum* Bonord. Hdbk. Allg. Myk. 116. 1851.

? *Nematogonium simplex* Bonord. Hdbk. Allg. Myk. 117. 1851.

Mucor dichotomus Bref. Bot. Unters. 4: 95. 1881.

Sporodinia aspergillus Schroet. Syll. Fung. 7: 207. 1887.

This species has been frequently described by different authors, as the above synonyms indicate. The name *Syzygites* was given to the zygospor-bearing mycelium while the name *Sporodinia* was applied to the part producing the sporangia.

If the identity of Haller's plant were absolutely sure, his name would have to be substituted for the name given above.

This reddish-brown mould is easily recognized and very generally found on decaying *Boleti* and other fungi.

SUBSTRATA: On decaying agarics, *Boleti*, *Polyperi*.

SPECIMENS EXAMINED: Canada, *Anderson* 622; Maryland, *Fung. Columb.* 1494; Massachusetts, *Farlow* 1487; New Jersey, *Ellis* 2279; Pennsylvania, *Sumstine*; Virginia, *Murrill*.

ILLUSTRATIONS: Bull. l. c. pl. 480, f. 3; Pers. l. c. pl. 6, f. 5; Bref. l. c. pl. 6, f. 23-25; Bainier, Étude, pl. 4, f. 1-10.

9. CIRCINELLA Van Tieghem & Le Monnier, Ann. Sci.

Nat. V. 17: 298. 1872

ORIGINAL DESCRIPTION: Le filament fructifère est recourbé en crosse au-dessous du sporange qui est ainsi réfléchi vers le bas. . . . En outre, le développement de leur appareil fructifère aérien est indéterminé, et, comme les *Rhizopus* et *Chaetocladium*, elles végètent en guirlandes à la manière des Lianes.

Le sporange, ainsi réfléchi le long du filament qui le porte, est de forme sphérique, et muni d'une grande columelle cylindro-conique; sa membrane est incrustée de granules d'oxalate de chaux, non diffuente, et à la maturité elle se déchire circulairement vers son milieu, en laissant une large cupule hémisphérique autour de la base de la columelle pour laisser échapper un grand nombre de petites spores sphériques. (In part.)

Type species, *Circinella umbellata* Van Tieghem et Le Monnier.

Sporangiophores growing singly from the mycelium, not terminated by a sporangium, with lateral, fascicled or single, circinate branches terminated by a sporangium with columella; zygosporous borne on distinct sporangiferous filaments.

I. CIRCINELLA UMBELLATA Van Tieghem & Le Monnier, l. c. 300.

1872

Mucor umbellatus Schroet. Krypt. Fl. Schles. 3: 206. 1886.

The clusters of sporangia on the principal sporangiophores enable one to identify this species.

. SUBSTRATA: On dung of lion, horse, jaguar.

SPECIMENS EXAMINED: New York, *Sumstine*; Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Van Tieghem & Le Monnier, *l. c.* *pl.* 21, *f.* 18-23; Bainier, *Étude*, *pl.* 6, *f.* 1-7; Bainier, *Bull. Soc. Myc. Fr.* *pl.* 7, *f.* 10.

10. THAMNIDIUM Link, Ges. Naturf. Freunde
Berl. Mag. 3: 31. 1809

ORIGINAL DESCRIPTION: Sporangium globosum. Stipes tubulosus, septatus, basi ramosissimus, ramorum apicibus sporidia nuda sustentantibus. Hoc genere series quae a Mucedinibus incipiebat, iterum ad Mucedines redit. Sporangium mucoris, peridio tenuissimo, aqua adfusa rumpente et sporidia majuscula, globosa effundente.

Stipes Mucedinum basi quoque in ramis dichotomis vera Mucedinum sporidia nuda profert, ita ut revera ambigua sit planta.

Type species, *Thamnidium elegans* Link.

Sporangiophores erect, terminated by a sporangium, with several dichotomously divided branches; the terminal sporangia many spored with columella; sporangioles on the dichotomous branches with few spores and without columella; zygospores formed on the mycelium, naked, copulating branches straight.

I. THAMNIDIUM ELEGANS Link, *l. c.* 1809

Melidium subterraneum Eschweiler, De Fruc. Gen. Rhiz. 33.
1822.

Mucor elegans Fries, Syst. Myc. 3: 322. 1829.

Ascophora elegans Corda, Ic. Fung. 3: 14. 1839.

This beautiful species is easily recognized by the two kinds of sporangia and by the dichotomous branches. It is seldom reported from this country.

Bachmann (Bot. Zeit. 107. 1895) describes six different typical forms cultivated on different substrata.

SUBSTRATA: On dung of tiger and horse.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Link, *l. c.* *pl.* 2, *f.* 45; Eschweiler, *l. c.* *pl.* *f.* 10; Corda, *l. c.* *pl.* 2, *f.* 43; Bref. Bot. Unters. 9: *pl.* 2, *f.* 1-8; Bainier, *Étude*, *pl.* 8, *f.* 1-5; Nees, Sys. der Pilze, *pl.* 6, *f.* 75.

II. BULBOTHAMNIDIUM Klein, Verh. Zool.-bot. Ges. Wien

20: 557. 1870

Chaetostylum Van Tieghem & Le Monnier, Ann. Sc. Nat. V. 17: 328. 1873.Type species, *Chaetostylum Fresenii* Van Tieghem & Le Monnier.

ORIGINAL DESCRIPTION: Die aufrechte Fruchthyphye zeigt bei *Bulbothamnidium* unterhalb der Spitze eine unregelmässig kugelige oder ellipsoidische Anschwellung, aus welcher rundherum viele Seitenzweige zweiter Ordnung entspringen, die abermals unter der Spitze eine Anschwellung zeigen, aus welcher erst viele kurze Zweige 3. Ordnung entspringen und die kugeligen Sporangiolen tragen. Ausser dieser Grundform finden sich noch einige Modificationen derselben und zwar kommt es vor, dass die Haupthyphye keine Anschwellung zeigt, sondern dass die Seitenzweige zweiter Ordnung wirtelig als gewöhnliche Verzweigungen entstehen, und sich dann im Uebrigen ebenso verhalten, wie im ersten Fall. Weiter findet man Haupthyphen mit mehreren Anschwellungen über einander, diese aber sind einseitig, aus denselben entspringen wieder viele Seitenzweige zweiter Ordnung, welche unter der Spitze eine allseitige Anschwellung zeigen, aus welcher dann, wie im ersten Fall die kurzen Sporangiolen tragenden Zweige dritter Ordnung ausgehen. Die Anschwellung kann auch an den Aesten zweiter Ordnung nur einseitig sein, wie es in Fig. 17 bei *b* zu sehen ist, während gleich über dieser Stelle noch eine allseitig Anschwellung zu finden ist.

Type species, *Bulbothamnidium elegans* Klein = *Ascophora pulchra* Preuss.

Sporangiophores erect, terminated by a sporangium with columella, with numerous side branches terminated by sterile ends; sporangiferous branches springing from swellings or bulbs, sporangioles without columella; zygosporos unknown.

I. *Bulbothamnidium pulchrum* (Preuss).*Mucor Mucedo* Fres. Beitr. zur Myk. 96. 1860. (In part.)*Ascophora pulchra* Preuss, Linnaea 24: 139. 1851.*Bulbothamnidium elegans* Klein, l. c. 1870.*Chaetostylum Fresenii* Van Tieghem & Le Monnier, l. c. 1873.

Thamnidium chaetocladioides Bref. Bot. Unters. 4: 57, 58. 1881.

Thamnidium Fresenii Schroet. Krypt. Fl. Schles. 3: 210. 1886.

The branches growing from swellings on the principal sporangiophores are very characteristic of the genus and the species. My specimens have longer branches than the measurements given in the various descriptions cited but otherwise they agree.

SUBSTRATA: On decaying *Polyporus* among other moulds.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fresenius, l. c. pl. 12, f. 13-16; Van Tieghem & Le Monnier, l. c. pl. 23, f. 61-63; Brefeld, l. c. pl. 2, f. 5; *idem*. 9: pl. 2, f. 9-18; Bainier, *Étude*, pl. 7, f. 1-7.

2. *Bulbothamnidium pulchrum variabile* var. nov.

On a piece of beef kept in a refrigerator at a temperature of 40° Fahr. there appeared a dense growth of mould in the autumn of 1908. A careful examination failed to identify it. The sporangiophores were simple, unbranched, 5-15 mm. high, white to grayish white; sporangia large, gray with a greenish hue, spherical; columella cylindrical with collarette; spores elliptical, 6-12 μ , often larger in the same sporangium. The material was set aside and marked new species.

A year later the same plants growing under similar conditions were again found. From this material cultures were made on sterilized bread. The culture proved very perplexing; instead of a simple sporangiophore, there appeared branched sporangiophores as in *Bulbothamnidium pulchrum*. In all, sixteen cultures were made and exactly the same result was obtained in each culture. Ordinary beef (not sterilized) was then inoculated with spores from the original plants and kept at a temperature of about 40° Fahr. The simple sporangiophores were produced in these cultures.

The mode of branching, the shape and the size of sporangium, columella and spores agree fairly well with *Bulbothamnidium pulchrum* and therefore I do not feel justified at present in describing it as a new species. The variability in the form of the sporangiophores on different substrata and under different conditions seems to merit a new form.

SUBSTRATA: On beef and sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

Diagnosis: Hyphae sporangiferae simplices, non ramosae, erectae, candidae, 5-15 mm. altae; sporangia magna, candida, viridi-flava, sphaerica; columella cylindrica; sporaе variae in magnitudine, ellipticae, 6-12 μ .

Hab. In bubula.

12. *HELICOSOTYLUM* Corda, Icon. Fung. 5: 18, 55. 1842

ORIGINAL DESCRIPTION: Hyphasma decumbens, ramosum, continuum. Stipes erectus spiraliter incurvatus, simplex, continuus, dein deciduus. Sporangium acrogenum, membranaceum, stipite adfixum dein deciduum, rumpens. Columella nulla. Sporaе irregulariter conglobatae continuae, episporio simplici, nucleo firmo, guttulis oleosis repleto.

Type species, *Helicostylum elegans* Corda.

Sporangiophores erect or decumbent, terminated by a sporangium with a columella; branches spirally and irregularly arranged along the sporangiophores, terminated by a sporangium without columella. The zygospores are unknown.

SPECIES REPORTED

1. *Helicostylum cyaneum* Pound and Clements, Bot. Survey Neb. 4: 5. 1896.

13. *CALYPTROMYCES* Karst. Bot. Zeit. 20: 365. 1849

Pleurocystis Bonord. Hdbk. Allgemein. Myk. 124. 1851.

Type species, *Pleurocystis Fresenii* Bonord. = *Mucor racemosus* Fres.

Chlamydomucor Bref. Bot. Unters. 8: 228. 1890.

Type species, *Mucor racemosus* Fres.

ORIGINAL DESCRIPTION: Peridiola globosa, membranacea, circumscissa, in floccis terminalia, nucleos centrales, persistentes, sporidiaque includentia. Sporidia subglosa discreta. Flocci tubulosi, erecti, septati ramosi vel simplices. Thallus ramosus, vesiculis, farctus vel cellulosus.

Type species, *Calyptromyces ramosus* Karst.

Karsten was the first to establish a separate genus for branching Mucors. Two new species are described under this genus,

Calyptromyces ramosus and *simplex*. The former is well described and figured. He also describes and illustrates the germination of the spores and the chlamydospores.

Bonorden described a genus for short-branched Mucors. Five species are listed under the genus. The first, *Pleurocystis ascendens*, is described and figured as new. This may be an abnormal form of the Karsten species. *Pleurocystis fungicola*, which is the same as *Ascophora fungicola* Corda, is probably referable to *Calyptromyces ramosus*. *Pleurocystis Helicostylum* and *Candelabrum* are placed under other genera. This still leaves *Pleurocystis Fresenii*, which Bonorden says is synonymous with *Mucor racemosus* Fres.

This complex group contains some forty described species but the relationship of these species is not well known. There seem to be two modes of branching, monopodial and sympodial. This branching has been made the basis for the division into two groups, Racemo-Mucor and Cymo-Mucor (see Fischer, *l. c.* and Lendner, *l. c.*). This division, however, is uncertain and unsatisfactory.

A number of the species produce in addition to the zygospores, azygospores. Of the species referred to this genus by European authors 6 produce azygospores, 6 zygospores only and in 29 neither zygospores nor azygospores have been observed. Of the 12 species whose zygospores or azygospores are known, eight belong to the section Racemo-Mucor. Of the 4 remaining species, one is imperfectly described and the branching not definitely known, one is closely allied to the genus *Circinella*, one has zygospores closely resembling azygospores, and one is described as monopodially and sympodially branched.

Vuillemin has established a new genus (see *Zygorhynchus*) for two species of this section. The formation of the zygospores is the basis for the separation.

When the zygosporic or the azygosporic characters of the 29 remaining species are known some of them may be referred to the genus *Calyptromyces*, others to the genus *Zygorhynchus*, and others may have sufficient differences to justify the establishment of a new genus or even new genera.

Cultures in known media will in all probability aid in deter-

mining the line of cleavage between genera as well as between species.

The azygospores indicate a tendency to eliminate the sexual method of reproduction. Investigation along this line may aid in solving some problems in the evolution of plants and possibly determine more clearly the phylogeny of the Mucoraceae.

In more than one half of the species there are also developed oidiospores and chlamydospores. These may have some taxonomic value when they are more clearly understood.

The limits of this genus are possibly best left undetermined for the present except as defined in the original description. It seems that most of the species listed in Section 2, *Racemo-Mucor*, by Fischer *l. c.* and Lendner *l. c.* should be placed in this genus.

KEY TO THE SPECIES

Sporangiophores with short, straight or very slightly bent branches.

1. *C. ramosus*.

Sporangiophores with rather short circinate branches.

2. *C. circinelloides*.

Sporangiophores with usually long branches.

Columella globose or nearly so.

3. *C. erectus*.

Columella piriform with spines.

4. *C. plumbeus*.

Columella piriform without spines.

5. *C. globosus*.

I. CALYPTROMYCES RAMOSUS Karst. *l. c.* 1849

? *Mucor juglandis* Link, Ges. Naturf. Freunde Berl. Mag. 3:

30. 1809.

? *Mucor truncorum* Link, Ges. Naturf. Freunde Berl. Mag. 3:

30. 1809.

Mucor racemosus Fres. *l. c.* 1850.

Pleurocystis Fresenii Bonord. *l. c.* 1851.

Chlamydomucor racemosus Bref. *l. c.* 1890.

Link describes two branching *Mucors* that seem to agree with the species under consideration but it is impossible to say definitely that his plants are identical with Karsten's plants. If these plants are the same then Link's name would have to be substituted for the name given above.

The height of the sporangiophores varies from 5-50 mm. The branches are usually short and straight. The columella may be globose or oval. The spores globose or elliptical. The chlamydospores and oidiospores are very numerous. Both zygospores and azygospores have been observed.

SUBSTRATA: On bread, mule dung, potato.

SPECIMENS EXAMINED: New York, Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Karst. *l. c. pl. 6*; Fres. *l. c. pl. 1*; Fischer, *l. c. f. 30*.

2. ***Calyptromyces circinelloides*** (Van Tieghem).

Mucor circinelloides Van Tieghem, Ann. Sci. Nat. VI. 1: 94.

1875

The branches are circinate but all terminate with a sporangium. This species seems to connect with the genus *Circinella*. Fischer *l. c. 205* describes the zygosporos.

SUBSTRATA: On bread.

SPECIMENS EXAMINED: New York, Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Bainier, *l. c. pl. 7, f. 9-15*; Hagem, Unters. Norweg. Mucor. 1: 36.

3. ***Calyptromyces erectus*** (Bainier).

Mucor erectus Bainier, Ann. Sci. Nat. VI. 19: 207. 1884.

This species differs from the preceding by the longer branches, by the elliptic and unequal spores. Zygosporos and azygosporos have been observed (see Bainier, *l. c.*).

SUBSTRATA: On ground flaxseed.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

4. ***Calyptromyces plumbeus*** (Bonord.).

Mucor plumbeus Bonord. Abh. Naturf. Ges. Halle 8: 109. 1864.

Mucor spinosus Van Tieghem, Ann. Sci. Nat. VI. 4: 390. 1876.

The spines growing on the top of the columella are very characteristic of this species. The only other species known to have a spinescent columella is *Mucor spinescens* Lendner. The latter differs from the former in the smaller sporangiophores.

SUBSTRATA: On beef broth, bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*.

ILLUSTRATIONS: Fischer, *l. c. f. 30 e*; Bainier, *l. c. pl. 7, f. 1-8*.

5. ***Calyptromyces globosus*** (Fischer).

Mucor globosus Fischer, *l. c. 202*. 1892.

This species was found by Walter Kerr, a student in the Pittsburgh High School, by exposing boiled potatoes for *Mucor* spores.

The specimens agree very well with Fischer's description except in the shape of the columella. This is given as piriform but my specimens have variously shaped columellas, piriform, obovate, panduriform. The sporangia are globose, at first greenish-yellow, at maturity brown to black.

SUBSTRATA: On boiled potato, sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Kerr*, *Sumstine*.

SPECIES REPORTED

1. *Mucor ambiguus* Vuillemin, Bull. Soc. Nancy 92. 1886.

This species is reported by Kauffman (Ann. Rep. Mich. Acad. Sci. 8: 28. 1905). It was found on mummied plums.

14. *ZYGORHYNCHUS* Vuillemin, Soc. Myc. Fr. 19:

114, 115, 116. 1903

ORIGINAL DESCRIPTION: Filaments du thalle continus, ramifiés, inégaux, parfois noueux, plongeants, rampants ou formant un-duvet aérien cotonneux. Chlamydospores lisses, intercalaires ou terminales. Pédicelles isolés ou groupés sur des systèmes sym-podiques irréguliers qui portent des sporocystes normaux, des sporocystes abortifs et des zygosporés. Pas d'apophyse. Sporocystes uniformes, à membrane plus ou moins conrescente avec la base de la columelle, plus ou moins incrustée d'oxalate de calcium, plus ou moins diffluente. Quand la membrane est fugace, elle laisse à la base une collerette. Spores nombreuses, petites lisses. Zygosporés fortement hérissées, rostrées. Tympan d'in-sertion subopposés, inégaux, le plus petit au sommet du rostre. Suspenseurs inégaux et dissemblables, le petit droit et court, le grand long, courbe, termine par un renflement piriforme. Gametes très inégaux. L'appareil zygosporé naît sur un système de filaments aériens, comme les sporocystes.

Type species, *Mucor heterogamus* Vuillemin.

The development of the zygosporés from unlike and unequal copulating branches characterizes this genus.

1. *ZYGORHYNCHUS* MOELLERI Vuillemin, l. c. 117. 1903

Mucor Moelleri Lendner, Mucor. Suisse 72, 1908.

The type species of the genus has not been found since its

first discovery in 1886. This second species was found in 1902. It differs principally in the smaller elliptic spores, smaller zygosporcs, and depressed columella. Azygosporcs and chlamydo-spores are rather abundant.

SUBSTRATA: On sterilized bread.

SPECIMENS EXAMINED: Pennsylvania, *Sumstine*. (Only in laboratory cultures.)

ILLUSTRATIONS: Lendner, *l. c.* f. 25.

ADDITIONAL GENERA

The following genera have been established somewhat recently by European authors but no species of these genera have yet been reported for America. An enumeration of these genera may interest students of the American Mucoraceae.

1. *Pirella* Bainier, Ann. Sci. Nat. VI. 15: 84. 1882.

Type species, *Pirella circinans* Bainier.

The zygosporcs are unknown. It is very near the genus *Circinella*.

2. *Dicranophora* Schroet. Jahresb. Schles. Ges. Vaterl. Cultur. 64: 198. 1886. (Not available.)

Type species, *Dicranophora fulva* Schroet.

This species has been found only by Schroeter, on *Paxillus involutus*.

It may be recognized by the principal sporangia with central columella and numerous spores and by the sporangioles on dichotomous branches with forked columella and few spores. The zygosporcs have very unequal suspensors.

3. *Tieghemella* Berlese & De Toni; Sacc. Syll. Fung. 7: 215. 1888.

Type species, *Absidia repens* Van Tieghem.

The zygosporcs are unknown.

4. *Mycocladius* Beauverie, Ann. de Univer. de Lyon 162-180. 1900.

Type species, *Mycocladius verticillatus* Beauverie.

This has been placed by Lendner in the genus *Absidia* although the zygosporcs do not have the cuticularized threads or filaments.

5. *Proabsidia* Vuillemin, Bull. Soc. Myc. Fr. 19: 116. 1903.

Type species, *Mucor Saccardoi* Oudemans.

The zygosporae have the characters of the genus *Absidia*.

6. *Lichtheimia* Vuillemin, Bull. Soc. Myc. Fr. 19: 126. 1903.

Type species, *Mucor corymbifer* Cohn.

The zygosporae have not been observed.

7. *Parasitella* Bainier, Bull. Soc. Myc. Fr. 19: 153. 1903.

Type species, *Parasitella simplex* Bainier = *Mucor parasiticus* Bainier.

The specific name has been changed in the transfer to the new genus. The zygosporae are not known.

8. *Glomerula* Bainier, Bull. Soc. Myc. Fr. 19: 154. 1903.

Type species, *Glomerula repens* Bainier.

From the description and figure, this seems very different from the other known *Mucors*.

9. *Pseudo-Absidia* Bainier, Bull. Soc. Myc. Fr. 19: 155. 1903.

Type species, *Absidia dubia* Bainier.

The specific name is changed to *Pseudo-Absidia vulgaris* Bainier. This is generally referred to the genus *Absidia*.

THE SCHWEINITZ COLLECTION OF MUCORS

In his Synopsis of North American Fungi, Schweinitz lists under the genus *Mucor* seventeen species, Nos. 2726-2742, as follows, *Mucor fimetarius*, *rufus*, *flavidus*, *Mucedo*, *ascophorus*, *tenuis*, *carneus*, *minimus*, *tenellus*, *caninus*, *stercoreus*, *murinus*, *Fimbria*, *albo-virens*, *truncorum*, *capitato-ramosus*, *echinophila*; under *Thamnidium*, one species, No. 2743, *Thamnidium elegans*; under *Pilobolus*, two species, Nos. 2227-2228, *Pilobolus crystallinus*, *roridus*.

All these numbers are missing in the Herbarium of the Academy of Sciences, Philadelphia, and therefore further consideration is out of the question.

There are some unnumbered packets in this herbarium that belong to the Schweinitz collection. The specimens were presumably collected by him. The following is a list of these specimens with my notes.

1. *Mucor rufus*. No specimen in the packet but the label reads "*Mucor rufus* in *Boleto*." This was probably *Syzygites aspergillus*.

2. *Mucor minimus*. The name *tenellus* also appears on the

label but has been crossed out. There is nothing on the substratum to indicate the presence of a *Mucor*.

3. *Mucor tenuis*. The packet contains small pieces of discolored wood.

4. *Mucor albo-virens*. No specimen in the packet.

5. *Mucor caninus*. No specimen in the packet but inside the packet is written "*Mucor stercoreus*, Beth., *Aspergillus flavus*, Salem."

6. *Mucor Fimbria*. Packet empty.

7. *Mucor ascophorus*. No specimen in the packet but an additional label reads, "*Ascophora Mucedo*."

8. *Mucor truncorum*. Only a few stems (sporangiophores ?) were found. Impossible to identify.

9. *Mucor capitato-ramosus*. This was a new species. A remnant of the host, possibly a *Polyporus*, was the only thing found in the packet. See under *Syzygites aspergillus*.

10. *Mucor echinophila*. This is also described as a new species. The specimens are all gone and the identity is uncertain. The description is brief and inadequate. See Schweinitz, l. c. No. 2742.

11. *Syzygites megalocarpus*. The packet is empty, but in all probability he had *Syzygites aspergillus*.

12. *Phycomyces nitens*. A few sporangiophores clearly indicate this species.

13. *Thamnidium elegans*. Not this species, whatever it is. The material is too scanty for identification.

14. *Pilobolus crystallinus*. The packet contains some dried manure but there is no evidence of this species.

THE BERKELEY AND CURTIS SPECIES

In Grevillea 3: 148-149, the following new species are described from America by Berkeley and Curtis:

1. *Mucor paradoxus*. This plant was collected by Michener in Pennsylvania on decaying *Boletus*. "The Flocci are short, hyaline, the vesicles (sporangia) of two kinds, the larger globose on longer flocci, the smaller obovate but narrow on short pedicels springing from the mycelium."

In Sacc. Syll. Fung. 7: 211, this is placed under the genus

Thamnidium by Berlese and De Toni. From the description, it is impossible to tell where it belongs.

2. *Mucor Cucurbitarum*. This was collected in South Carolina by Ravenel and in New England by Sprague, on decaying gourds and melons. The habitat and the description point to the common *Mucor Mucedo*.

3. *Mucor Beaumontii*. Beaumont collected this species in Alabama on decaying cabbage leaves. The spores are said to be dark purple, otherwise it may be referred to *Mucor Mucedo*.

4. *Mucor curtus*. This was found on decaying muskmelon in South Carolina. The spores are "fusiform with a minute appendage at either end, binucleate, .00057 long, about $\frac{2}{3}$ as much wide." This is surely not a *Mucor*.

5. *Ascophora fusca*. This species was described in the Journal of the Linnaean Society 10: 363. 1868. It was collected in Cuba on fruit of *Atrocarpus*. The sporangia are described as "*globosis dein collapsis umbraculiformibus*." The collapsed, umbrella-shaped columella indicates *Mucor Mucedo*, or some species of this genus.

STATE LISTS OF FUNGI

In addition to the references and citations already made, the following lists of fungi were consulted but specimens of the species enumerated in these lists were not examined by the writer and therefore they are not included in the present paper.

ALABAMA: Underwood and Earle, Preliminary List of Alabama Fungi. 1897.

CALIFORNIA: Harkness and Moore, Catalogue of the Pacific Coast Fungi. 1880.

CUBA: Ramon de la Sagra, Icones Plantarum in Flora Cubana Descriptarum. 1863.

GREENLAND: Rostrup, Fungi Groenlandiae. 1888.

MASSACHUSETTS: Tuckerman and Frost, A Catalogue of Plants growing without cultivation within thirty miles of Amherst College. 1875.—Farlow, Bulletin of the Bussey Institute. 1876.

MAINE: Ricker, A Preliminary List of Maine Fungi. 1902.

NORTH CAROLINA: Curtis, Geological and Natural History Survey of North Carolina. Part 3. Botany. 1867.

OHIO: Kellerman and Werner, Catalogue of Ohio Plants.
Geology of Ohio. 1895.

PENNSYLVANIA: Herbst, Fungal Flora of Lehigh Valley. 1899.

WEST VIRGINIA: Millspaugh and Nuttall, Flora of West Virginia. 1896.

HIGH SCHOOL,
PITTSBURGH, PENNSYLVANIA.

A NEW POLYPORE ON INCENSE CEDAR

GEORGE GRANT HEDGCOCK

During the past three years the writer has repeatedly searched in California and Oregon for the cause of the "peckiness" or "pin-rot" of the incense cedar, which does great injury to the heartwood of this species, and often affects as high as 100 per cent. of the trees in a given area. The fungus whose description follows was found definitely associated in an apparently causal relation to the disease.

Dr. Hermann von Schrenk described this disease of the incense cedar under the name "pin disease" (Mo. Bot. Gard. Rept. 11: 45-55, *pl.* 2, 4, 5, June 3, 1899), without giving the cause. He later assigned the cause of the disease to *Polyporus libocedrus* (Science N. S. 16: 138, 1902), but, in the absence of type specimens and a description, there is no means of knowing whether or not his specimen and those now described belong to the same species.

Polyporus amarus sp. nov.

Pileus soft and spongy when young, becoming hard and chalky when old, unguulate, often spuriously stipitate from knot-holes, frequently large, 5-11 × 10-20 × 6-12 cm.; surface pubescent when young, rimose and chalky when old, at first buff, becoming tan and often blotched with brown when older; margin obtuse, frequently having an outer band of darker brown, often slightly furrowed; context creamy-yellow to tan-colored, usually darker in outer layers when old, bitter to the taste and often resinous near the base, somewhat like *Fomes Laricis* (Jacq.) Murr., 4-8 cm. thick; tubes not stratified, brown within, cylindric, 0.5-3 cm. in length, shorter next the margin, mouths circular or slightly irregular, 1-3 to a mm., yellow or yellow-green during growth, turning brown when bruised or old, becoming lacerate; spores hyaline or slightly tinged with brown, smooth, ovoid, 3-4 × 5-8 μ , nucleated; cystidia none.

TYPE LOCALITY: East slope of Marble Mt., Klamath National Forest, California. Specimens collected October 14, 1909; other specimens collected near Dunsmuir, Calif., October 16, 1907.

HABITAT: Living trunks of *Libocedrus decurrens*, causing the pin-rot or peckiness of the heartwood of these trees.

DISTRIBUTION: California and Oregon.

Type specimens are deposited in the pathological herbarium, Bureau of Plant Industry, United States Department of Agriculture, Washington, D. C.

TIMBER AND FOREST DISEASE SURVEY,
WASHINGTON, D. C.

NEWS AND NOTES

Dr. E. J. Durand, instructor in botany at Cornell University, has been appointed assistant professor of botany in the University of Missouri.

Professor G. F. Atkinson, of Cornell University, visited the Garden April 21, to consult some of the older mycological literature.

Dr. George G. Hedgcock, of the National Timber and Forest Disease Survey, spent ten days at the Garden in April, consulting the collections of timber-destroying fungi.

The chair of botany at the University of Vermont has been filled by Dr. George P. Burns, of the University of Michigan.

Dr. Perley Spaulding, of the division of Forest Pathology at Washington, made the Garden a brief visit in April to examine the collection of plant rusts.

Mr. Frank Dunn Kern, associate botanist of the Agricultural Experiment Station at Lafayette, Indiana, has been appointed fellow in botany at Columbia University for the ensuing collegiate year.

Miss E. C. Field, scientific assistant in the Bureau of Plant Industry, Washington, D. C., was at the Garden nearly two weeks in April, consulting the collections of parasitic fungi.

A scientific expedition to Colombia is being organized at Neuchâtel, the leader being Dr. O. Fuhrman, professor of zoology at Neuchâtel University. Dr. Mayor will accompany the expedition and devote his attention mainly to the parasitic flora.

Several specimens of *Pluteus cervinus* were found April 9, growing in a sawdust pile not far from Bronx Park, New York City. The only other fleshy fungi noticed were *Coprinus micaceus*, which is usually the first to appear in quantity in the spring, and the common winter species, *Collybia velutipes*. All of these species are described and figured in the first volume of this journal.

Owing to the excellent series of specimens of *Pyropolyporus praerimosus* Murrill recently collected by Dr. George G. Hedcock and his assistants on various species of oak and walnut in Texas, Arizona, and New Mexico, it is now possible to connect this species with *Pyropolyporus Everhartii* (Ellis & Gall.) Murrill as a variety of the latter; the very rimose character being probably due to desiccation, as is the case with western forms of *P. igniarius*, particularly the one found commonly on aspen. It often happens that more complete collections will connect species that at first appear both morphologically and geographically distinct.

"Resolved, That the American Phytopathological Society views with alarm the recent introduction into America of two dangerous European plant diseases: The potato wart, caused by *Chrysophlyotis endobiotica* Schilb., and the blister rust of white pine, caused by *Peridermium strobi* Klebahn. The former has been discovered in Newfoundland. The latter has been widely distributed in nine of the United States and in the Province of Ontario, but is now believed to have been eradicated.

"Resolved, that the society deplors the fact that, in the absence of any national regulation in either the United States or Canada, both governments are powerless to prevent the continued introduction of these and other dangerous diseases, or their transference from one country to the other.

"*Resolved*, that on account of the enormous financial interests involved in potato culture and in white pine reforestation, this society regards the situation as very alarming, and one which warrants radical and immediate action. Even if these diseases do no more harm in America than they have in Europe, the situation is serious; but every law of biology and all experiences with plant diseases and pests indicates that, in a new climate, with new varietal and specific hosts, and with an entire continent in which to spread, both diseases will reach a degree of virulence unknown in Europe.

"Therefore, *Resolved*, that this society pledges its support to all legislation in both the United States and Canada looking toward the inspection, quarantine or prohibition from entry, as may be necessary, of all plant material liable to introduce these or other dangerous diseases or pests."

(Signed) F. L. STEVENS,
President.

